Green Infrastructure, Ecosystem Service and the Enablers and Barriers for Implementation within Wine-Grape Vineyards

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A thesis

submitted in partial fulfilment

of the requirements for the Degree of

Master of Natural Resource Management and Ecological Engineering

at

Lincoln University

by

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Lincoln University

2020

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Viticulture is often a monocultural, production-based cropping system that results in a loss of biodiversity, ecosystem services and resiliency within the agricultural system. Green infrastructure (GI) provides an opportunity for viticulturists to gain ecosystem services and increase biodiversity within their farming systems to reduce the impacts of this monocultural system. However, despite many studies on green infrastructure and the ecosystem services GI can provide, there is a lack of literature on the enablers and barriers for the implementation of green infrastructure in vineyards. This research project aims to address this gap with four main research questions; What green infrastructure is planted in vineyards and vineyard/wineries and where is it located? What private and public ecosystem services and disservices does the green infrastructure provide? What are the enablers and barriers for planting green infrastructure in vineyards? And finally, how might the amount of green infrastructure, and its associated services be increased in wine grape vineyards and vineyard/wineries? Nineteen vineyard owners and vineyard managers were interviewed from the Waipara Valley, New Zealand. These interviews used a semi-structured interviewing technique to explore research questions. During interviews cover crops, shelterbelts, nature conservation and insectary habitats were the most common green infrastructure components identified by participants. The ecosystem services that growers associated with each of these components varied in detail with production orientated services being the most frequently mentioned. This study finds that recognition of ecosystem services, access to knowledge regarding implementation, management benefits and consequences to farm practice, level of commitment to greening and access to funding

are the core enablers and barriers for implementing green infrastructure in wine-grape vineyards. These enablers and barriers have implications for those aiming to initiate greening projects within viticultural communities such as certification schemes, government organisations and large corporates.

Keywords: Green Infrastructure, Vineyards, Enablers, Barriers, Ecosystem Service, Greening Implementation.

Acknowledgements

"You'll be probably frightened at times, scared, worried. You'll hate it, you'll absolutely despise the fact that you're involved and when you get to the finish, you'll know why: because there's nothing like it. It gets in the blood and you can't get rid of it."-Sir Peter Blake

The quote above sums up most of my feelings regarding research. During the process of writing a thesis, I have been frustrated, worried, scared, and I've even hated some parts. However, getting to the end, I now look back fondly and look forward to conducting further research. Thank you to my friends, flatmates and family for reminding me that nothing worth having comes easy, for encouraging and supporting me when times were hard. Words can't explain how humble this has made me over the past two years, so I'll just leave it at a very sincere thank you.

I would like to mention the participants in this study for their time, frank answers and willingness to participate in this research project. It is thanks to their comments that I was able to build a picture of what green infrastructure is present and what the potential enablers and barriers are.

To my supervisors, Wendy McWilliam and Olaf Schelezki. Thank you for your guidance and patience throughout this project; it has meant a lot. To Colin Meurk and Marianne Penker, my co-supervisors. Thank you for your participation and advice throughout this project. I would also like to thank Nadege Grisard for her assistance during the interview process.

Finally, thank you to Lincoln University for the opportunities and scholarships that I received during this process. They have been invaluable to my academic and professional development as a researcher and will prove to be even more valuable moving forward.

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Chapter 1

Introduction

Conventional vineyards are monocultural in design and utilise artificial inputs and machinery to focus on high yields and to produce on land that previously may have been unviable (Sandhu et al., 2010). This form of viticulture has many negative impacts on the environment such as; simplification of the landscape and loss of ecosystem services (Shields et al., 2016). In the past, modernist agriculture has aimed to remedy the effects that a productivist system has on the land by using two concepts. These concepts are substitution efficiency agriculture and biodiversity agriculture (Duru et al., 2015). Incorporating multiple biodiversity strategies into farm systems has been promoted by scholars (Rey Benayas and Bullock, 2012, Meurk and Swaffield, 2000). Strategies have demonstrated its benefits for mitigating environmental impacts such as chemical use (Christ and Burritt, 2013), ecosystem impacts (Paiola et al., 2020) and soil erosion (Winter et al., 2018), but also for providing additional ecosystem services, such as biological pest control (Altieri et al., 2005), increasing soil quality (Winter et al., 2018) and increasing cellar door experience and marketing opportunities (Fountain and Tompkins, 2011). These strategies may involve both increasing the number of products and services on vineyards, and the restoring green infrastructure (G.I.) on vineyard farms. Taken from urban development and modified for a viticultural setting, the term green infrastructure here refers to a network of natural and semi-natural and man-made non-vine vegetation that may or may not contribute directly or indirectly to production and provide private and/or public ecosystem services to vineyards and their communities (McWilliam, 2020).

The viticulture industry internationally is aware of the impacts of the productivist system. As a result, sustainable, organic, industry-based and biodynamic certifications have developed schemes and handbooks around sustainable practice (SWNZ, 2018). However, despite this movement to include more green infrastructure in the vineyard system, the uptake and implementation of such goals are not as rapid or consistent as expected. There is a multitude of studies in the literature focusing on

individual green infrastructure components and their associated benefits such as cover crops, insectaries, riparian plantings, hedgerows, and cellar doors. However, a gap in the literature exists surrounding the enablers and barriers for implementing green infrastructure successfully and continuously in the vineyard (McWilliam, 2020). This thesis aims to address this gap by researching green infrastructure, its associated ecosystem services and the enablers and barriers for its implementation in the vineyard using qualitative methods to do so.

1.1 Research Questions and Objectives

This thesis will answer four research questions by achieving five research objectives:

1.1.1 Research Questions

1. What green infrastructure is planted in vineyards and vineyard/wineries and where is it located?

2. What ecosystem services and disservices does the green infrastructure provide?

3. What are the enablers and barriers for planting green infrastructure in vineyards?

4. How might the amount of green infrastructure, and its services be increased in wine grape vineyards and vineyard/wineries?

1.1.2 Research Objectives

1. To describe the theory surrounding green infrastructure in vineyards internationally and, in particular, in New Zealand.

    1.1. What environmental impacts are associated with productivist viticulture?

    1.2. What strategies and/or management practices are being promoted and/or implemented in vineyards and vineyard/wineries to reduce these impacts?

1.3 What are the associated ecosystem services and disservices with green infrastructure in vineyards?

1.4. What are barriers and enablers to implementation of green infrastructure?

2. To identify what green infrastructure is being implemented in wine-grape vineyards.

3. To determine the recognised ecosystem services of green infrastructure by vineyard owners and managers.

4. To identify the enablers and barriers for the implementation of green infrastructure within vineyards and vineyard wineries.

5. To identify and discuss the implications of the research for improving the performance and implementation of G.I. in the vineyard.

1.1.3 Organisation of this Thesis

This thesis is divided into six chapters. The first chapter has introduced the topic explored in this thesis and describes the research questions and objectives that are addressed throughout this study. The second chapter provides a review of the relevant literature around the impacts of production-orientated viticulture, possible ecosystem (dis)services that can be provided by green infrastructure in a vineyard setting and the enablers and barriers that have been discussed in other vineyard studies and environmental management textbooks. The second chapter is followed by a methods section providing the qualitative methods that this study follows. The fourth chapter in this thesis provides the results of this study by outlining the location, ecosystem (dis)services recognised by the vineyard managers/owners and the enablers and barriers related to each component of green infrastructure. The fifth chapter discusses the results of this study in terms of the current literature. The sixth and final chapter concludes the study, discussing the implications of the results for implementing green infrastructure and what further research is required.

Chapter 2
Theory of green infrastructure for mitigating environmental impacts, ecosystem service provision and the enablers and barriers for implementation within vineyards

Chapter two reviews the literature regarding the use of green infrastructure (GI) for mitigating the environmental impacts of wine grape production, for providing other ecosystem services to vineyards, markets and communities and looks at the enablers and barriers for implementation that are addressed in the current literature. Section 2.1 describes the environmental impacts associated with conventional wine grape production systems. Section 2.2 critically evaluates the science in support of the strategies used to reduce these impacts. Section 2.3 discusses the ecosystem services that have been associated with the GI researched in the literature. Section 2.4 looks at how current certifications encourage GI within their recommended and required practices. Section 2.5 explores the barriers and possible enablers explored in the various literature available. Finally, this chapter concludes with a summary of the points discussed above.

2.1 Environmental impacts associated with conventional wine-grape production systems

Conventional viticulture is often not recognised by consumers as having a high cost to the environment (Delmas and Grant, 2014). Christ and Burritt (2013) carried out an integrative literature review suggesting that the following areas are of concern: water quality and use, solid waste, energy use and greenhouse gas emissions, land use issues and impact on ecosystems. In this review, they highlight that the wine industry faces a large number of environmental issues that have gone largely ignored, by the media, by regulators, by consumers, and sometimes by the winery operators themselves. They also suggest that because of this negligence, there is strong potential for academic research in this area. Finally, they conclude that for the wine industry to remain sustainable, it must continue to address and improve its environmental performance.

A result of a production-orientated system or intensive viticulture designed to meet yield demands is the simplification of the landscape resulting in a monoculture with loss of biodiversity, patch

functionality, ecological integrity and natural character (Meurk and Swaffield, 2000). This results in a loss of resilience within the system both ecologically and financially (Gagliardi and Pettigrove, 2013, Muhammed et al., 2018, Altieri et al., 2005, Bruggisser et al., 2010). This loss of resiliency causes increased vulnerability of the crops to pests and disease, which can be financially devastating (Altieri et al., 2005). Monocultures such as those seen in production orientated vineyards simplify the landscape, which causes growers to compensate for the loss of service by using more pesticides to control pest populations. Increased use of pesticides can have severe impacts on the environment. Altieri et al. (2005) also report that biodiversity can contribute in many ways to a stable environment, as biodiversity creates an ecological infrastructure within and around the vineyard. Altieri et al. (2005) support this statement by reporting that the implementation of biodiversity is crucial for crop defences as the more diverse the plant-animal and soil-borne organisms are in the system, the more diverse the population of the beneficial organism will be. This is consistent with niche theory: i.e. the more niches that are available, the more species a system can support without competitive exclusion occurring (Fitzpatrick and Martinez, 2012).

It has been suggested that the viticulture industry has a higher level of chemical use when comparing the total area planted alongside other forms of commercial cropping systems (Saint-Ges and Bélis-Bergouignan, 2009).Pesticide, herbicide and fungicide use is identified within the literature as an issue that is also associated with vineyards (Christ and Burritt, 2013, Altieri et al., 2005). Chemical inputs in vineyards include synthetic fertilisers, pesticides and herbicides (Forbes et al., 2009, Silverman et al., 2005). The use of these chemical inputs has many negative impacts on the environment, such as contaminating surface and groundwater, loss of soil fertility, reduction in insect populations including beneficial insects as well as unintended consequences to the growers such as spray drift and resistance to sprays (Christ and Burritt, 2013). Silverman et al. (2005) also identified chemical sprays as having harmful impacts on vineyard workers neighbours and animals sharing the local habitat. A second significant issue with synthetic fertilisers is leaching through conducive soils with potential to contaminate local water supplies through inappropriate or excessive application.

Many wine regions are growing in size, causing tensions in wine regions, particularly in new-world regions where there is growing pressure from community groups regarding land use issues (Pullman et al., 2010, Christ and Burritt, 2013). This pressure from community groups stems from a concern regarding biodiversity loss (Paiola et al., 2020), localised pollution and contamination (Gagliardi and Pettigrove, 2013), as well as the possible impact on neighbouring properties and the market value of the surrounding land areas (Christ and Burritt, 2013). These concerns are often fuelled by the substitution of water-intensive vineyards for other activities such as dryland farming (Christ and Burritt, 2013). A recent New Zealand example of this is the Waimea Dam Project (Neal, 2017). This conflict between producers and the public highlights the industries' need to project their commitment to sustainability and the protection of the landscape in order to gain a social licence to farm (Barber et al., 2009). New Zealand Winegrowers (NZ Wine) have made steps towards this goal with 98% of New Zealand Winegrowers being SWNZ (Sustainable Winegrowers New Zealand) accredited, which has provided a market and brand advantage within overseas markets (New Zealand Tourism, 2012, Pratt, 2012).

2.2 Strategies for reducing the environmental impacts of conventional wine-grape production systems

Within the literature, many strategies and land management practices have been promoted to benefit the environment and to reduce the impacts caused by a production-based model of viticulture. These impacts can be overcome by land sharing (wildlife-friendly farming) and land sparing practices, efficiency substitution method and biodiversity-based farming including the term green infrastructure. The sections below critically explore each strategy.

2.2.1 Land Sharing and Land Sparing

Land sharing and land sparing are two common approaches to promoting biodiversity conservation and agricultural production. Land sharing also referred to as wildlife-friendly farming practices, refers to an approach where biodiversity is integrated into the farming system (Fischer et al., 2008). Characteristics of land sharing landscapes include patches of native plantings spread throughout the

landscape with farmed areas that are structurally similar to native vegetation to achieve a high level of spatial heterogeneity (Fischer et al., 2008). Land sparing can be summarised as having a sharp contrast between land for agriculture and land for biodiversity (Fischer et al., 2008), resulting in agricultural areas being used intensively to achieve high yields but allowing for land to be set aside for permanent preservation of species-rich areas nearby (Green et al., 2005). Both of these approaches have positives and negatives. Land-sharing means that little space is left for permanent conservation of habitat and species, as more land is needed to achieve yields. Also, land-sharing farming practices may only be suitable for species that can persist in a "soft matrix" landscape (Green et al., 2005). On the other hand, land-sparing often means that areas of land will be utilised and used in a production-orientated method to achieve maximum yield in a minimal space, which could result in more detrimental environmental impacts on that space (Fischer et al., 2008).

2.2.2 Efficiency Substitution Strategies

Following a demand for higher yields to be reached in a sustainable way, many agricultural practices have been explored and implemented in order to achieve this goal (Wezel et al., 2014). Efficiency increase refers to a practice that reduces input consumption of resources such as water, pesticides and fertilisers while also improving crop productivity (Wezel et al., 2014, McWilliam, 2020). In contrast, substitution refers to the substitution of an input or a practice for another, for example replacing chemical pesticides with natural pesticides (Wezel et al., 2014). Organic fertilisation is another example of substitution for inorganic fertilisers and a method of improving the efficiency of fertilisation by improving general soil fertility (Wezel et al., 2014). Wezel et al. (2014) suggest that substitution may lead to a necessary redesign of the system. This is due to the application of organic fertiliser causing enhanced soil biological activity and potentially increasing soil mineralisation. Substitution practices involving organic fertilisers may result in higher labour and energy demands, and difficulty in optimising nitrogen availability in soils with organic fertilisation as well as in matching plant demand (Sanchez et al., 2004). In vineyards, these strategies also focus on reducing synthetic pesticides and best practices in integrated pest management are being adopted

internationally (Gabzdylova et al., 2009). Sustainable certified producers are also substituting organic pesticides, herbicides and fertilisers instead of conventional synthetic options, and biodynamic certified farmers are reducing fossil fuel use (Villanueva-Rey et al., 2014). This is also applicable to SWNZ (Sustainable winegrowers New Zealand) certified vineyards, as SWNZ encourages the substitution of sprays, and highly recommends cover crop usage and biological control of pest species within the vineyard (SWNZ, 2003). However, it has been suggested that these substitution and efficiency strategies are not adequate as they do not address some environmental impacts, such as the support of indigenous biodiversity and system resiliency (McWilliam, 2020).

2.2.3 Biodiversity-Based Strategies

Biodiversity strategies can involve the diversification of production systems. Unlike substitution and efficiency strategies, which include "correcting" farming conditions through artificial inputs, additional production systems that align with the heterogeneous growing conditions of their land, are introduced (McWilliam, 2020). This can result in increased biodiversity and a decrease in external inputs (McWilliam, 2020). Biodiversity strategies can also encourage ecosystem services to be provided at the field, farm and landscape levels depending on the level of biodiversity. Emerging as a new concept within agriculture management, the term green infrastructure (GI) can be described as the implementation of a network of natural and semi-natural non-vine vegetation that contributes directly or indirectly to production and provides private and/or public ecosystem services to vineyards and their communities (McWilliam, 2020). The terms greening and green infrastructure are closely linked. Greening is a term that originates from landscape architecture where it is used to describe the integration of plants into the urban setting to create green spaces such as parks, gardens, and greenways for the enhancement, preservation, and protection of these ecosystems (De Sousa, 2014). This greening concept has since moved into the agricultural settings to increase the biodiversity of these areas, gain ecological services and meet the growing demand for good practice within the industry (Gabzdylova et al., 2009, Silverman et al., 2005). There are three main aspects that form the concept of green infrastructure. These are the idea of a network of areas, a

component of planning and management as well as the gaining of ecosystem service (Liquete et al., 2015, Silva and Wheeler, 2017). Similar to biodiversity-based farming, green infrastructure focuses on the provision of ecosystem services. However, it also builds on this idea by creating a network within the system by utilising both sharing and sparing techniques to do so. Green infrastructure within the vineyard includes components such as vegetated buffer strips, inter-row cover crops, woody vegetation such as remnant forest, hedgerows and nature conservation patches (McWilliam, 2020). This integration of biodiversity through green infrastructure increases spatial and temporal heterogeneity within the vineyard, which increases the resiliency of the system (Paiola et al., 2020). Resilient systems reduce risks of pathogen transmission, pest outbreaks and increase buffering variations in climate (McWilliam, 2020, Paiola et al., 2020).

2.3 Ecosystem Service and Disservices Associated with Green Infrastructure

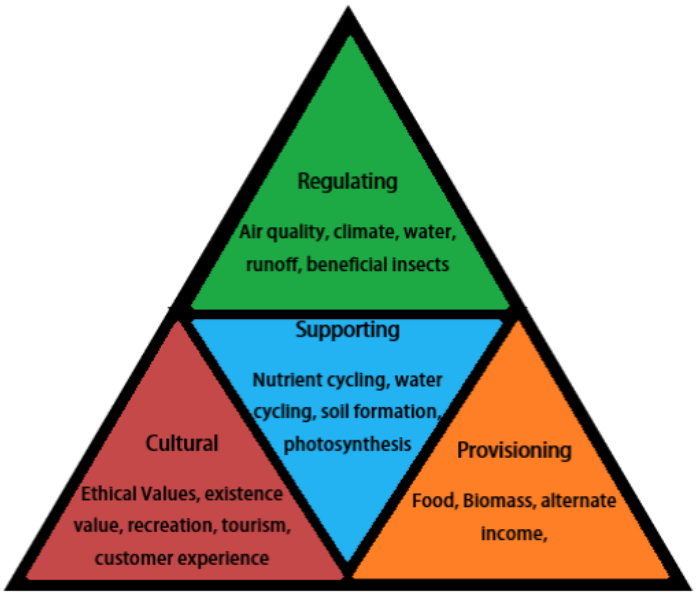

Figure 1 Ecosystem service categories with examples of vineyard services.

Green Infrastructure and its individual components have the potential to provide multiple ecosystem services within the vineyard setting. Ecosystem services are the processes through which natural ecosystems help sustain human life (Reece and Campbell, 2011). These services can be placed into four categories: regulating, supporting, provisioning and cultural. Within the vineyard, these services can be classified as input orientated services and output related services (Figure 1). Green infrastructure has the potential to provide an abundance of benefits within the vineyard setting using components such as cover crops, hedgerows, native insectary patches, water corridors and patches (Paiola et al., 2020, Winkler et al., 2017). These components and their related ecosystem services are

well studied within the literature relating to vineyards. The services related to landscaped plantings and fallow land in vineyards are less studied. The following sections will outline each of these components and the potential ecosystem services provided by each component that is currently explored within the current literature.

2.3.1 Cover Crops and Swards

The term cover cropping is the term used to describe plant cover between rows of vines to provide multiple ecosystem services (Daryanto et al., 2019). Sward is the term used in farming to describe the upper layer of soil, especially when covered with grass (Pearsall, 2001). In a vineyard, sward refers to the grassed area between rows of vines. Cover crops and swards are both used to gain ecological services in the vineyard environment. A meta-study by Winter et al. (2018) that found that extensive inter-row management that involved the use of vegetation increased both above ground and below ground biodiversity and ecosystem service provision by 20% when compared to intensive management. The ecosystem services that they associated with inter-row management were soil erosion, biodiversity, carbon sequestration, biological pest control, and soil fertility. The study also reported no trade-off between grape yield and quality with ecosystem service and biodiversity. However, they did acknowledge that the effect of inter-row management on vine development would depend on variables such as vine age, irrigation and vintage conditions. Garcia et al. (2018) reported a disservice of competition between their service crops between rows and the vines, this is in opposition to the findings of (Winter et al., 2018). Jacometti et al. (2007) studied the use of the cover crop species phacelia and ryegrass that was mulched between the crops during the winter months. This mulching between vines aimed to increase the rate of soil biological activity to break down the vine debris that Botrytis (*Botrytis cinerea*) overwinters in. The results of this study showed that there was potential for mulched cover crops to enhance soil ecosystem services, reduce variable costs and increase the level of sustainability within the vineyard due to reduced *B. cinerea* primary inoculum on the debris and a decrease in *B. cinerea* severity at flowering. This finding supports Winter et al. (2018)'s statement that inter-row vegetation management can benefit the soil and

improve biological control within the vineyard. Despite this knowledge about cover cropping in the vineyard being available, a literature search did not result in any qualitative studies that explore the attitudes of the growers towards the implementation of these cover crops in the vineyard. However, Daryanto et al. (2019) discuss the possibility that indirect costs, economic pressure, availability of labour, lack of education, training and technical assistance may be significant barriers to cover crop implementation, especially given the management complexity that comes with the introduction of cover cropping to a typical farming operation.

The inter-row and vineyard boundary areas may also provide habitat for bee species. It has been found that the area within 750m of the vineyard block plays a role in the forgeability for bee species in the inter-row region (Kratschmer et al., 2018). These bee species are important within the Austrian landscape represented in this study as they provide pollination to wild plants and crops. As such, this study suggests that semi-natural elements such as fallows or solitary trees providing floral resources and nesting habitat should be preserved within viticulture landscapes. Kratschmer et al. (2018) also acknowledge the role of cover crops and continuous sward cover for the provision of floral resources for wild bees. The presence of pollinator species in vineyards has been shown to enhance overall biodiversity, biological control and soil quality (Wratten et al., 2012).

2.3.2 Hedgerows and Shelterbelts

Hedgerows can be defined as shrubs and occasional tree species that typically border a road or field edge (Barnes, 2006). The term shelterbelts refers to a line of tree or shrub species planted to protect an area from fierce weather (Pearsall, 2001). Shelterbelts and hedgerows can provide ecosystem services such as nitrogen and phosphorus removal, reduction of soil erosion, microclimate mitigation and possible habitat for beneficial species (Van Vooren et al., 2017). However, there are also ecosystem disservices that can occur due to the presence of these structures. Van Vooren et al. (2017) reported in their study that the higher the trees, or the more narrow the area of used cropland, the higher the weight of the negatively affected zone will be. This implies that when implementing shelterbelts within their vineyard systems, it is important for the growers to include

the shape of their field and the height of the tree species in their calculations. Hedgerows also provide habitat for avian species (Heath et al., 2017). This habitat provides an opportunity for agricultural landscapes to play a role in the conservation of these species through the provision of habitat suitable to accommodate wildlife. However, frugivorous bird presence in vineyards can also be detrimental to production and have significant financial costs (Saxton, 2006). It is suggested within the literature that choosing appropriate hedgerow species and implementing predatory bird perches and habitats that this disservice can be mitigated (Peisley et al., 2017, Saxton, 2006).

2.3.3 Nature Conservation and Insectary Habitats

There is a large body of literature that describes ecosystem services provided by patches and corridors of vegetation. However, within the literature there are multiple terms that are used to describe these patches and corridors, such as woody vegetation (McWilliam et al., 2017), insectaries/beneficial insect patches (Araj and Wratten, 2015, McWilliam, 2020), riparian margins (Cooper et al., 1995, Dosskey et al., 2010), native vegetation (Paiola et al., 2020), natural remnants (Paiola et al., 2020) and nature conservation habitats (McWilliam, 2020). All of these terms have a commonality of providing ecosystem services through the presence of vegetation. The inclusion of vegetated patches such as those listed above is important for both ecosystem service provision and biodiversity conservation. New Zealand native plants not only provide regulating and provisioning services but also cultural services. Shields et al. (2016) suggest that New Zealand native plants can be integrated into the under-vine areas within vineyards. The native plants used in their Waipara study to provide ecological services can be seen in Table 1 below, along with the ecosystem services and the ecological disservices most associated with each of the native plants studied.

		Ecosystem associated benefits				
		ES	ES	ES	ESP	EDS
Plant species	Family	Weed suppression	Invertebrate Conservation	Improving soil quality	Enhansing predator densities	Pest development
Acaena inermis	*Rosaceae*	+	+		+	
Acaena inermis 'purpurea'b	*Rosaceae*	+	+	+	+	+
Anaphalioides bellidioides	*Asteraceae*	+	+		+	+
Disphyma australe	*Mesembryan-themaceae*		+		+	
Geranium sessiliflorum	*Geraniaceae*	+	+	+	+	+
Hebe chathamica	*Plantaginaceae*	+	+	+	+	+
Leptinella dioica	*Asteraceae*	+	+	+	+	+
Leptinella squalida	*Asteraceae*	+	+		+	
Lobelia angulata	*Lobeliaceae*	+	+	+	+	+
Muehlenbeckia ephedroides	*Polygonaceae*		+		+	
Muehlenbeckia axillaris	*Polygonaceae*	+	+	+	+	+
Raoulia hookeri	*Asteraceae*	+	+		+	+
Raoulia subsericea	*Asteraceae*		+		+	
Scleranthus uniflorus	*Caryophyll-aceae*	+	+		+	+

Table 1 Endemic plant species used in the vineyard trial and the ecosystem associated benefits assessed (Shields et al., 2016).

The study by Shields et al. (2016) was carried out in conjunction with the Greening Waipara Project. As a part of this study, they conducted surveys of viticulturists on ecosystem services provided by New Zealand endemic plants. The surveys conducted found that growers who had not employed native plantings would definitely or maybe include native plantings for the services included in Table 1 above.

Insectaries along with native plantings provide a sanctuary for many beneficial insect species. An insectary is an area of planting that aims to act as a source or a sink for beneficial insects within the ecosystem to provide ecosystem services to the vineyard (Wilson et al., 2015, Duelli and Obrist, 2003, Altieri et al., 2005). Biological control refers to the use of natural predators to reduce pest species populations; pest species that impact vineyards include leafroller, light brown apple moth and the mealybug. Wilson et al. (2015) studied the influence of riparian habitat on western grape leafhopper populations. They found that there were no significant differences in leafhopper density between the vineyard edge and interior. However, the first and second generation nymph populations were consistently lower on the vineyard edge. A subsequent result of the plantings used

on the vineyard was reduced vine vigour, which was most likely related to changes in the microclimate and competition with non-crop plants that are associated with the riparian habitat (Wilson et al., 2015). Nicholls et al. (2001) studied the effects of a vegetation corridor on the abundance and dispersal of insect biodiversity. Nicholls et al. (2001) also reported that the presence of riparian habitats aided predator colonisation and abundance on adjacent vineyards, this benefit was however limited by the natural predator's dispersal distances. This highlights the need for a connected network for maximum ecosystem service.

One study was carried out looking at the effects of fragmentation of the agricultural landscape on butterfly populations. It was noted that many farmland features such as hedgerows, field margins and remnant patches of native vegetation are of importance to butterfly populations (Schmitt et al., 2008). A New Zealand study by Gillespie and Wratten (2012) found that remnant native patches had the most species richness within their Waipara study sites and that these remnant patches may provide the closest approximation to 'natural habitat' for New Zealand butterflies in lowland agricultural settings. Prior to Polynesian settlement, endemic butterflies such as *L. salustius* are likely to have persisted close to their host plants in seral shrubland communities maintained by browsing flightless birds such as moa. This provides an insight into the cultural heritage value that these remnant or scrubby patches can provide to both the growers and the public, highlighting the need for the conservation of these areas.

2.3.4 Waterways and Ponds

Water corridors and patches typically contain vegetated patches. Within the literature the term riparian is frequently used. Riparian planting refers to the use of pre-existing or planted vegetation to conserve waterways (Daigneault et al., 2017). Riparian planting has become more prevalent in agricultural and pastoral industries including viticulture due to the importance of reversing the effects of production-orientated systems becoming imperative to the sustainable goals of the industry (McKergow et al., 2016). It has been documented by McKergow et al. (2016) that the implementation of riparian buffers is often a compromise between maintaining productive land and

a range of ecosystem services. In New Zealand, riparian plants are typically an assemblage of native species such as sedges, *Carex* species; Flax, *Phormium tenax*; Cabbage Tree, *Cordyline australis*; and various native shrubs (McKergow et al., 2016). There are many ecosystem services related to riparian planting including sediment, nutrient and microbial mitigation; stream bank stabilisation; contamination removal; shade and temperature control; fish and invertebrate habitat; and the creation of stable and diverse waterway food webs (Cooper et al., 1995, Collins et al., 2013, Davies-Colley et al., 2009, Dosskey et al., 2010, Hughes, 2016). Although riparian planting is well studied in relation to the dairy sector, there is limited literature regarding vineyard waterways. Riparian planting fits into the green infrastructure definition as it creates a network of plantings along waterways that provide ecosystem services (Daigneault et al., 2017). However, it is not described as green infrastructure in these studies, which may be due to the concept of green infrastructure only recently becoming prevalent in agricultural research topics.

Vineyards and wineries require large inputs of water during the grape growing and winemaking process. This water may require treatment as it contains sugars, ethanol, phenolic compounds and tannins which can pollute soil and water if discharged untreated in the environment (Masi et al., 2015, Serrano et al., 2011, Shepherd et al., 2001). One method of filtering winery wastewater discharge is by using the ecosystem services provided by wetlands (Masi et al., 2015, Serrano et al., 2011, Pappalardo et al., 2016). Introducing a constructed wetland (CW) into a vineyard is a low cost, low maintenance, and energy-saving option for the vineyards to develop as a part of their green infrastructure systems (Masi et al., 2015). Some vineyards have pre-existing wetland areas on their property which allows them to actively conserve and protect these areas to gain ecosystem services from them. Examples of vineyards conserving wetland areas are Wither Hills in Blenheim with the Rarangi Wetlands (New Zealand Wine, 2019), Yealand wines' Seaview Vineyard with 25 wetlands created in the Awatere Valley (Yealands, 2019) however, these wetlands are not used for wastewater treatment. Grove Mill vineyard is also another example of a wetland area being conserved within a vineyard; they established a wetland area for the conservation of the Southern Bell Frog in their vineyard (Grove Mill, 2019). The presence of these wetland areas within these vineyards is used to

sell the story of the wines that each vineyard is producing, which helps create a sustainable ethos within the vineyard and across the region as more vineyards follow suit. By constructing or preserving a wetland, vineyards are adding green (blue) infrastructure to their properties as it creates a network of plants within the system that provides the grower with ecosystem services both directly and indirectly within their vineyard.

2.4 Role of Vineyard Certifications for Encouraging Green Infrastructure

Environmental issues within agriculture have recently gained more public attention, resulting in more research and adoption of environmental innovations that reduce water pollution, groundwater depletion, the toxicity of pesticides, habitat destruction and loss of biodiversity (Cullen et al., 2013). In response the viticulture industry is increasingly focusing on developing more sustainable practices and techniques to increase biodiversity within the vineyard landscape (Paiola et al., 2020). A result of the industries' recognition of the need to change to more sustainable practices, along with pressure from both consumers and community groups, certifications such as organic, biodynamic and other sustainable certifications have become more prominent (Moscovici and Reed, 2018, Merli et al., 2018). Certifications provide guidelines for growers for sustainable practice as well as an advantage within the market as consumers look for quality, price and story when purchasing wine (Moscovici and Reed, 2018). Examples of certifications within the wine industry include Organic, Demeter, UTZ Certification, Salmon-Safe, Sustainable Winegrowing New Zealand (SWNZ) and LIVE Wines (Moscovici and Reed, 2018, McWilliam, 2020, Forbes et al., 2009, SWNZ, 2018). SWNZ is an industry-wide certification programme that is led by New Zealand Winegrowers. As a member of SWNZ, each vineyard is required to meet certain standards regarding the use of sprays, complete a farm plan and undergo reviews on their practices. SWNZ also provides the growers with a comprehensive handbook with information regarding sustainable vineyard practices. This handbook suggests that biodiversity is an important factor in vineyard health and stability, and that growers work on creating and conserving an ecologically diverse and balanced vineyard to gain services such as biological control of pests and boosting soil structure and quality (SWNZ, 2003). Membership of

and compliance with the SWNZ program gives members access to all New Zealand Wine events, promotions, and awards (Pratt, 2012). As a result, 98% of New Zealand's producing vineyard area is accredited to SWNZ with an additional 3-5% of the vineyard area operating under other certified organic programmes (New Zealand Tourism, 2012). BioGrow is New Zealand's common organic certification with Assure Quality being another alternative. BioGrow is not a whole farm organic approach. The BioGrow manual places great importance on soil quality mentioning that soil health is a keystone of organics (BioGrow, 2009). However, green infrastructure is not a term mentioned within their viticulture module, although the use of swards is described as a method of protecting soil quality. Also, although not described in detail, the Biogrow manual also highlights habitats for beneficial insects as an important aspect of their organic practice, stating that suitable habitat for the natural enemies of pests must be present in the vineyard. Although strongly encouraged, most certifications focus on reducing inputs such as fertilisers, pesticides, and herbicides and don't have strong guidelines regarding levels of greening within the vineyard environment or how greening should be designed. Both the SWNZ and Biogrow vineyard handbooks place importance on the use of cover crops and sward cover between rows of vines alongside the substitution of chemical sprays for organic counterparts, while also encouraging vineyards to incorporate biodiversity within their vineyards. Certification for vineyards is often optional for growers; this increases their appeal to farmers as they provide a non-state, market based approach rather than a top-down governmental structure (Moscovici and Reed, 2018).

2.5 Barriers and Enablers for the Implementation of Green Infrastructure

Studies on the barriers to the implementation of green infrastructure are limited. However, Landis et al. (2000) studied habitat management as a method of increasing parasitoid and predator numbers in agricultural systems. In this study, the authors suggested that the implementation of successful insectaries as a form of ecological infrastructure had some barriers that needed to be overcome. Landis et al. (2000) suggest that there are five main barriers to consider: i) the selection of correct and appropriate plant species; ii) The predator/parasitoid behavioural mechanisms that are

influenced by the plantings; iii) The spatial scale that the habitat enhancement operates with implications for area , shape and spacing of resources and refuge for the predator species; iv) The negative aspects associated with adding the plant species into the agroecosystem; and v) The degree of uptake by the agricultural community of these proposed habitat changes. These five challenges provide an insight into why some agriculturists do not continue with greening projects, as plantings may not have received careful planning to ensure maximum benefit and the maintenance that is required for the establishment of the plantings may not be carried out sufficiently. There is an extensive amount of literature about different plant species that can be used as insectary plants and the patch dynamics for each species of parasitoid or predator (Shields et al., 2016, Tompkins, 2010, Berndt et al., 2002, Nicholas, 2004). However, these studies regarding insectary plantings were carried out on small scales and the benefits of these methods on a large scale are still largely unknown.

The study by Shields et al. (2016) mentioned above also surveyed growers to identify potential barriers for the use of endemic plants in the vineyard. They found a lack of knowledge, the cost of initial investment risk, disruption to normal vineyard practice and a lack of interest by the participants to be barriers for the implementation of native plantings. These findings are similar to the six barriers mentioned in the Landis et al. (2000) study above. A lack of knowledge could translate to Landis et al. (2000) first barrier, the selection of correct and appropriate plant species. Barrier number five and six from Landis et al. (2000), the negative aspects associated with adding the plant species into the agroecosystem and the degree of uptake by the agricultural community of these proposed habitat changes, also are implied in the barriers identified by Shields et al. (2016).

Another framework around the barriers for implementation of policy programs has been described using nine obstacles for implementation. Firstly, tractability is described as the complexity of the problem that the policy is solving, meaning that the effectiveness or resolvability of the problem will be affected. Secondly, a lack of clarity of goals is raised as a barrier as the implementation will be easier if a well-defined vision and set of goals is present. Thirdly, lack of commitment is a possible

barrier for implementation; Mitchell (2001) uses the example of when parties involved move forward tentatively or reluctantly. A lack of means is Mitchell (2001)'s fourth barrier to implementation; this is when the necessary tools or means to implement the policy or action are not available. Access to information is the fifth barrier mentioned; this is when different participants do not have access to information. Assumptions about cause and effect relationships is the sixth barrier; this is described as when a policy or program does not understand the causal linkages between stated objectives and activities. Dynamics of enforcement is listed as the seventh barrier; this is when the members implementing the policy at a field level and officials are more inclined toward negotiating to achieve compliance with regulation. Factors in developing countries are also listed as a barrier to implementation, referring to the obstacles that occur in developing counties at a higher rate than their developed counterparts. Finally, the ninth barrier is listed as cultural differences; this barrier is more pronounced when situations involve multilateral approaches in which two or more countries or parties must work together. Although this framework is general in its definitions and based on policy implementation, it also highlights some barriers that could be applied to both Shields et al. (2016)'s and Landis et al. (2000)'s findings regarding implementation.

Enabling factors are often opposites of barriers, as such the barriers identified above by Landis et al. (2000), Shields et al. (2016) and Mitchell (2001) can also be viewed as enablers. For example, New Zealand agriculturalists also have funding available for the planting of natives in the agricultural landscape for both the growers and community groups to access (Ecan, 2019, NZ Landcare Trust, 2019). The Waipara Greening project also had funding through a governmental biodiversity project as well as from external companies such as a manufacturer of health food products (Lincoln University, 2008). These contributions help to overcome the barrier of initial setup cost as listed above.

Consumer pressure for sustainable practices and products is discussed as a potential enabler for viticulturists to implement greening methods in their vineyards, as consumers become more aware of the impacts production orientated agriculture has on the landscape (Fountain and Tompkins,

2011, Forbes et al., 2009). This awareness has created a willingness to pay for sustainable attributes from the products they are purchasing (Tait et al., 2011, Moscovici and Reed, 2018). This willingness to pay creates an opportunity for those vineyards who meet certification requirements to take advantage of a premium price bracket for sustainable wines. Although one paper suggests that this may not always be the case and that the net cost benefits are often not significant enough, many growers may seek certification for social and moral reasons instead (Moscovici and Reed, 2018).

2.6 Summary

This literature review has explored the environmental impacts of production orientated viticulture on the environment. The literature suggests that the following areas are of concern: water quality and use, solid waste, energy use and greenhouse gas emissions, land use issues and impact on ecosystems (Christ and Burritt, 2013). The impact of viticulture on ecosystems is due to the simplification of the landscape and a loss of biodiversity with vineyards being a monoculture by nature (Paiola et al., 2020, Bruggisser et al., 2010). Due to these effects on the environment, many strategies are available to help reduce viticulture's impact on the environment. The strategies explored in this literature review were land sharing and land sparing, efficiency and substitution strategies, alongside biodiversity-based strategies including the use of green infrastructure (Fischer et al., 2008, Green et al., 2005, Wezel et al., 2014, McWilliam, 2020). Green infrastructure comes from an urban setting but is now being explored within the agricultural environment. Within the vineyard landscape GI was defined in the literature as the implementation of a network of natural and semi-natural non-vine vegetation that contributes directly or indirectly to production and provides private and/or public ecosystem services to vineyards and their communities(McWilliam, 2020). GI and biodiversity-based strategies aim to reduce the impact of production orientated viticulture by increasing biodiversity within the landscape to provide ecosystem services. The ecosystem services related to each component of GI researched in the literature was explored in this review. However, in alignment with the current literature, this review also found that many of the current studies focus on individual services provided by each component with few studies looking at

the multifunctionality of GI components. There is also a lack of literature regarding the ecosystem services that are recognised by the growers themselves. Another gap was also identified in the literature: few studies explore the enablers and barriers for the implementation of GI components in the vineyard setting (McWilliam, 2020). This review also explored the current literature regarding the barriers for the implementation of environmental policy, endemic plantings and habitat management in vineyards (Shields et al., 2016, Mitchell, 2001, Landis et al., 2000). The following chapter provides the methods used in this thesis to explore the four research questions outlined in chapter one.

Chapter 3

Methods

This chapter describes the research design and methods employed to achieve the research objectives. Section 2.1 describes the study area and vineyards involved in this thesis. Section 2.2 outlines the study methods used in this qualitative study. Section 2.2.1 describes the long interview process including the interview design process, an outline of the data collection and the data analysis that was carried out to answer the research questions and objectives.

3.1 Study Site

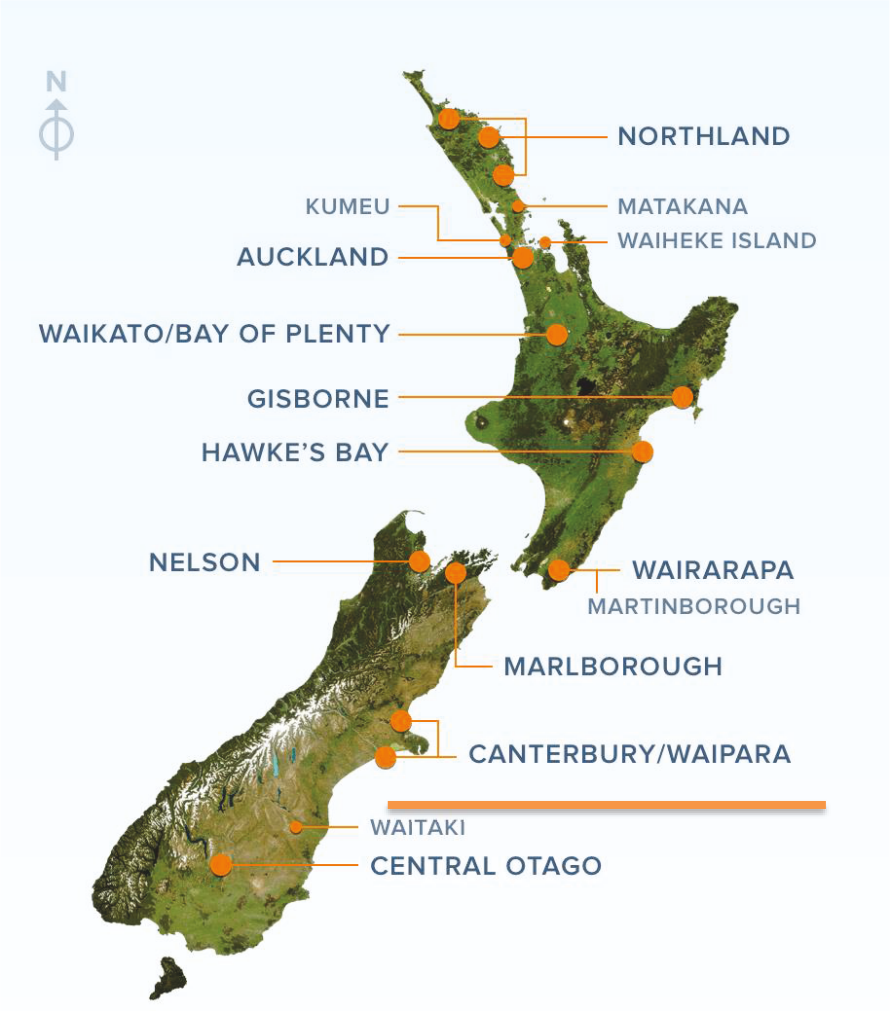

Figure 2 The Canterbury/Waipara region within New Zealand (NZWine, 2020)

The Waipara wine region, located in Northern Canterbury of the South Island In New Zealand (Figure 2) was selected as the location for this research. Waipara is the only region in New Zealand with a large number of vineyards who have implemented green infrastructure. Furthermore, the infrastructure was implemented in 2005 allowing sufficient time for the infrastructure to grow and for its ecosystem services to develop. Lincoln University and the Greening Waipara participants (55 winegrowers in Waipara) worked with the Hurunui District Council and Landcare Research to initiate the scheme in 2005 (Meurk et al., 2006a). The goal of the Greening Waipara scheme was re-establish native New Zealand plants within the Waipara landscape and to increase grower adoption of sustainable practices and reduce the use of pesticides (Fountain and Tompkins, 2011), participants also wanted to create a regional identity for the region to help with tourism and the recognition of Waipara wines. The Greening Waipara Project Published seven newsletters that participants had access to information and assistance for the implementation of their greening within their vineyards (Lincoln University, 2010). Another outcome of the Greening of Waipara was also a body of academic work and publications (Shields et al., 2016, Gillespie and Wratten, 2012, Landis et al., 2000, Meurk et al., 2006b, Cullen et al., 2013). The Waipara region itself is known predominantly for its pinot noir, chardonnay and resiling varietals and is made up of predominantly small family-owned vineyards with three large corporate companies also having a substantial footprint of vine area in the region.

3.2 Research Design

This research uses qualitative methods of data collection and analysis. Qualitative methods are beneficial for uncovering rich, detailed information regarding an issue (Creswell, 2007), which is required for exploring the complexity surrounding green infrastructure implementation among vineyards. A quantitative approach, such as the use of surveys, would not have been able to accomplish this, as it is beneficial largely for revealing broad numerical trends (Creswell, 2003). This research conducts personal interviews with vineyard managers and/or owners of vineyards in the Waipara region whose properties were involved in the Greening Waipara Project to answer the four research questions. Table 2 summarises the steps and methods utilised for accomplishing the research objectives.

Steps	Methods	Comments
To describe the theory surrounding the impacts of production orientated vineyard design and the science and implementation (including enablers and barriers) of green infrastructure and ecosystem service in vineyards.	Literature review	Objective 1 Chapters 2,5
To describe what green infrastructure is being implemented within study vineyards.	Inventory of green infrastructure within study vineyards and literature review	Objective 2 Chapter 2,4,5
To determine what ecosystem (dis) services interviewees attribute to their green infrastructure.	Social survey of key vineyard stakeholders and literature review	Objective 3 Chapter 4
To identify and evaluate the enablers and barriers to the implementation of GI in wine-grape vineyards	Social survey of key vineyard stakeholders and literature review	Objective 4 Chapter 4,5
To identify the implications of the research for improving the performance and implementation of G.I. in the vineyard.	Integrate results of literature review, inventory of vineyards and long interview results with vineyard stakeholders	Objective 5 Chapter 5

Table 2 Steps and methods used for evaluating what enablers and barriers exist for implementing green infrastructure in the vineyard setting.

3.2.1 Social Surveying: Long interviews with key vineyard stakeholders

To gain an understanding of what green infrastructure has been implemented, its significance to the viticulturists and the enablers and barriers for its implementation, this research project uses long interviews with key vineyard stakeholders. Structured techniques such as attitude surveys, opinion polls, questionnaires and interviews with pre-determined questions assure comparable findings (Taylor, 2016) but do not allow for explanation, clarification or probing into interviewee's answers (Louise Barriball and While, 1994). For this reason, a semi-structured long interview technique was

chosen as it allows for more exploration into the interviewee's experiences, perspectives and situations (Taylor, 2016, Creswell, 2007).

Interview Design

The interview script was developed taking into account Kallio et al. (2016) five-phase interview development guide. These five phases were; i) identifying the prerequisites for using semi-structured interviews; ii) retrieving and using previous knowledge from the literature to formulate question themes; iii) formulating the preliminary semi-structured interview guide; iv) pilot testing the guide (Gillham, 2000); v) presenting the complete semi-structured interview guide. They concluded that researches should consider using this five-step process to develop a semi-structured interview guide and to enable the researcher to justify the decisions made during the process of developing and choosing to carry out a semi-structured interview to achieve their research goals. These steps were used as a guide when developing the interview script (Appendix A.1), pilot testing was completed by testing the script between researchers and a viticulture technician the Lincoln University.

Data Collection

Interviewees were identified from a contact list of Greening Waipara participants. This list was shortlisted by identifying the vineyards that were no longer in business or had been purchased by other vineyard companies, resulting in a list of 24 vineyards to be contacted of which 19 vineyards agreed to participate. Following ethics approval, initial contact was made via both an email and a phone call. Following contact with appropriate interview candidates (the manager and/or owner of the vineyard) an interview time was organised, followed up with an email and text 48-24 hours before the interview. Interviews were carried out at the participant's vineyard consisting of a brief introduction and signing of the consent forms for their participation in the study. After the introduction, the first half of the interview was carried out using the interview script as a guide and probing interviewee answers as required. The initial stage was carried out in one location of the interviewees choosing. Following the interview, interviewees were asked if they were comfortable with the researchers walking around their property to identify and view the non-vine planting present, eighteen interviewees accompanied the researchers during the inventory analysis stage of

the interview. The inventory analysis stage of the interview provided more insight for answering the first research question (Deming, 2011). The intention behind this technique was to determine whether there was more green infrastructure that may be benefiting the property than what the interviewee recalled during the initial interview.

Data Analysis

Code	Role in vineyard/winery
V	Vineyard manager
VWO	Vineyard manager/Winemaker/Owner
VO	Vineyard manager and owner
VOC	Vineyard manager, owner and consultant
VW	Vineyard manager and winemaker

Table 3 Key to interviewee coding.

The participants of the study were coded into categories according to their roles within the vineyard/winery to allow for identification and also to ensure anonymity (Table 3). The interview scripts were transcribed into word documents verbatim with the average interview length being one hour and 20 minutes. Once transcribed each transcript was accompanied by a note-on-notes section as suggested by Loftland and Loftland (1995). This notes-on-notes section was a one-page summary of the initial thoughts and impressions gained from the interview to allow for initial themes and patterns to be identified during the interview stage of the study. Following data collection, the interview scripts were then coded repeatedly using the research questions as a guide until no new themes emerged; this was called the point of saturation (Gillham, 2000). These themes were then compared with the literature to explore the research questions further. Coding was carried out using software for qualitative studies called NVIVO. NVIVO allows the researcher to sort their coding into files called nodes. From the identified themes that are sorted into nodes, the researcher can easily determine the number of interviews that identified each theme and allows for the possibility of further analysis should it be required. During the coding stage, components of green infrastructure were identified and considered using the following categories, hedgerows/shelterbelts, cover crops/swards, vegetated patches, water corridors and patches and landscaped plantings. Interviewees were considered using the following identifiers; vine area, certification, ownership type, role within the vineyard, gender, education

background, presence/absence of cellar doors, attachment to the cycle trail and presence/absence of onsite guest accommodation (Appendix A.2).

Chapter three below provides the results of this thesis. The results chapter is separated into sections outlining the location and types of the GI components found in participating vineyards, the Ecosystem services identified by the participants, the ecosystem disservices identified by the participants and finally the enablers and barriers that were identified following analysis of the data. Three external enabling and impeding themes are also identified in the following chapter, they do not relate directly to one component of GI in the vineyards but were discussed by participants as possible enablers and barriers for GI implementation and management decisions in their vineyards.

Chapter 4

Results

This chapter is split into six sections; there is one for each of the five green infrastructure (GI) components, each providing the; location and type of GI identified by interviewees, the ecosystem services and disservices that interviewees associated with each component and the enablers and barriers that were identified during data analysis. The sixth and final section provides evidence for the enablers and barriers identified during data analysis that were not specific to particular GI components.

4.1 Cover Crops and Swards

Cover crops and swards were the most common green infrastructure components present and mentioned during the interview process, as all interviewees had either cover crops or sward cover present in their vineyards. Sward, in this case, refers to the presence of grass between rows of vines, including volunteer swards.

4.1.1 Location and Types

Volunteer swards were the most common ground cover between vines found across the region. Volunteer swards are where the area between the vines has been left to grow with no cultivation and the inter-row space is inhabited by spontaneous colonising plants (Figure 4).

> *"Everything's just got like what you call volunteer plantings which is just what grows, volunteer swards which is a pretty big, we've got a big mix of species here, but there was definitely clover in. Most of our Riesling block has got Lucerne in as well."-**V3***

Cover cropping of predominantly Buckwheat and Phacelia was used throughout some of the vineyards, with the species being sown at various spacing's down rows. Planting every 10th row was the standard practice (Figure 3).

> *"This year we planted 200 hectares of vineyard, in every tenth row we planted buckwheat and phacelia."-***V6**

One vineyard manager had used oat species as a cover crop in the past. However, the vineyard manager said the company who owned his vineyard has largely stopped this practice and replaced their cover cropping practice for meadow corridors with mown grass strips.

> *"We seem to as a company have gone off it [*cover cropping*] a wee bit. I'm not sure why. We used to use like oats which is really good. We did the oats for the nitrogen fixation. It's probably the big one."-**V8***

Clover was identified as both a volunteer species and as an active cover crop species, as two vineyards were intentionally seeding more appropriate clover species between their rows.

> "*We have got Clover in our rows as well as grass, but we were actually re-seeding some rows with sub-clover as well as some grasses. So because we don't want normal clover coz it gets really high."-**V6***

Figure 3 Cultivated mixed species (buckwheat, phacelia, oats and crimson clover) cover crop.

Figure 4 Volunteer sward with a mixture of Clover, Lucerne and flowering weed species.

4.1.2 Ecosystem Service Provision

Ecosystem services recognised by participants in this study in relation to cover cropping and sward inter-row management techniques were biological control and benefits to soil quality. Biological control refers to the reduction or mitigation of pest species and their effects through the use of natural enemies. Benefits to soil quality here refers to the services that the vineyard receives in terms of soil quality such as soil organic matter content, moisture control, mitigating soil compaction and increasing soil nutrients.

Biological Control

When asked about what benefits they were receiving from their non-vine plantings, the large majority of interviewees talked about beneficial insect populations as a result of their cover crops and volunteer swards. Interviewees were especially aware that cover crop species such as Buckwheat and Phacelia brought beneficial insects into their vineyards; this can be seen in the quotes by V1 and V4 below.

> *"We do a lot of planting down the rows in that Phacelia and Buckwheat and things for bringing in beneficial insects"-**V1***

One of the interviewees that was using Buckwheat and Phacelia as a part of their vineyard management routine were managing their cover crop in such a way to ensure that they were

receiving maximum benefit during the periods that they needed the services it provides. This meant they did not cut the crop during the summer season to ensure flowering up to harvest.

> *"So we have flowering all the way up to harvest as much as we can, because once the flower has gone. Well, as soon as a source of food is cancelled and your insects, you want to have, will go somewhere else."-**V4***

An interviewee who managed an organic vineyard believed that the use of Buckwheat and Phacelia in their vineyard was a contributing factor to controlling leaf roller populations given that they were unable to use many of the sprays available to conventional growers.

> *"Because we can't spray anything too toxic for the leafroller caterpillar, so it certainly helped us with that control of course."-**V2***

One vineyard manager pointed out that he thought the service beneficial insects provide by predating on the leafroller and mealybug was not a high priority service for Waipara due to the mealybug not being a problem. He did recognise that mealybug would eventually reach Waipara but didn't comment further on what this would mean when planning for the future.

> *"Insects. More of those ladybirds' types, wasps and whatever else that can eat the leafrollers and even I know they've got mealybug problems in Blenheim, but we haven't got them here yet, but they will eventually get here."-**V6***

Most participants were unclear on whether they believed they were receiving the beneficial services of the insects in their vineyards but recognised that the level of biodiversity in their volunteer sward was attracting more insects and that this was something they wanted during the flowering period.

> *"That's sort of like weeds, but you can see maybe ten different flower pods there, which I think is a good thing. Because it does bring insects and it brings, you know, we want the bees and at flowering"-**VWO1***

When this interviewee's beliefs around the service provision of beneficial insects were explored further, they were reluctant to confirm that the cover crop species or volunteer sward had played a role in keeping pest populations low.

*"It's hard to prove because we don't do…ten rows without any and ten rows with. We have a management strategy for the whole vineyard, so there's no comparison [between] that versus that."-**VWO1***

Benefits to Soil Quality

Interviewees were aware of the importance of looking after their soils. Benefits that they were interested in or believed they were receiving included; avoiding soil erosion, controlling moisture levels, mitigating compaction and increasing nutrient and organic matter in the soil itself. When probed further into what benefits they were looking for from their cover crops, interviewees also mentioned bringing nitrogen into the soil.

*"**Are you looking mostly on pest control or nitrogen**?... Yeah nitrogen there with the crimson clover and just general organic matter and the pest control."-**V6***

*"We did the oats for the nitrogen fixation. It's probably the big one."-**V1***

Organic matter in the soil was also a focus for many of the interviewees. Mulching pruning's into the soil and using cover crops to increase organic matter in the soil was a common goal of interviewees as they thought that composting was labour intensive and provided minimal net gain.

*"I decided we'll just focus more on cover cropping to build up our organic matter because I think trying to do it by compost is actually really a lot when you are working it out on per hectare. You have to apply phenomenal amounts of compost. So whereas you can grow up a cover crop and get quite good dry matter gains over a year, and it's all just there. You don't have to drive along and apply; it's just growing."-**V6***

A small proportion of interviewees mentioned that increasing organic matter in the soil would result in visible benefits throughout the vineyard blocks.

*"But just let alone the organic matter that's going back into the soil on those rows, you know it's useful, and I think you'll see that over the next few years."-**V6***

Another service interviewees were gaining from their green infrastructure was the control of moisture levels down the vineyard rows, this was important for management to ensure that farm machinery could be used between the rows without causing damage.

*"Between the rows, depends on which block everyone has got one grass row as an alternate row, and that's the rows we drive down as well coz it's a bit harder with the tractor to run it down through the dirt all the time, especially when it gets a bit wet. But then we have some wetter blocks we have extra grass and plantain, which includes some of those plants which put in some deeper roots to suck up some water and help control the moisture in those damper areas."-**V5***

*"It's probably what we've been looking for is whether can it take the moisture out of the soil for us, because on your wet blocks obviously, you want something like that in there."-**V3***

4.1.3 Ecosystem Disservice Provision

The only ecosystem disservice that was identified in regards to cover crops and swards was related to health and safety issues surrounding the cover crop that one vineyard had implemented in their vineyard.

Health and Safety Risks

In one case, the beneficial insect was viewed as a problem for the staff. The cover crop that was designed to attract wasps that predate on leaf roller caused a health and safety issue for staff working in the vineyard due to the bee and wasp population in the cover crop.

*"We actually found one flower, it became a hazard because it was summer and we had people in the summer and shorts crouching by the plants, we had to go and cut it down; it did what it was meant to do, but it became a hazard for our staff. So yeah, they said other issues you come across at the same time."-**V3***

4.1.4 Enablers and Barriers to Implementing Cover Crops and Swards

The enablers identified from the interviews for the implementation of cover crops and swards are recognition of the need for the ecosystem service that cover crops and sward cover provides; conversely the recognition or belief that a disservice may occur is a barrier for implementation. Knowledge regarding how to implement cover crops and swards and how to gain maximum service provision is also an enabler. The challenges and benefits in terms of impact on current vineyard management practices is also both an enabler and a barrier.

Potential for Ecosystem Service and Disservice Provision

Biological control and soil quality were the ecosystem services that interviewees recognised from cover crops and swards. However, some interviewees were also concerned about the impact that cultivating cover crops would have on their soils and for this reason, they did not implement cover crops. When discussing cover crops, one interviewee expressed they were not interested in cultivating or disrupting their soils as this would affect their soil profile.

> ***"Have you ever tried to sow buckwheat as Wratten recommended?*** *Yeah, and we decided we didn't want to disrupt the land would rather have the land as the land so leave it be.* W*e'd rather see the integrity of the soil profile that's been developed for the last few hundred thousand years not being deep ripped and cultivated and changed all the time."-**VWO1**.*

However, many interviewees recognised that cover crops would bring benefits to the vineyard due to the beneficial insects and thought that it would provide benefits for the soil as well. One vineyard had recently taken over their property and planned on planting a cover crop in the future to receive the benefits they believe cover crops provide.

> *"I think with the soils being how they are. Obviously, they've been in vine now for what 27 and 28 years. Yeah. So in that time, I don't think that they ever planted a cover crop in there or anything like that or even thought about it. But with the way that I'm trying to push the vineyard I can see it has been very beneficial because I mean it brings in all those insects and it brings in a lot of what's healthy for the soil as well, you know, so it's what I would find very beneficial."-**VW1***

Another vineyard also recognised that deep rooted cover crops could provide an ecological service within their vineyard by keeping the surface drier. They implemented cover crops with deep-rooted plantain specifically to transpire more water.

> *"We have some wetter blocks where we have extra grass and plantain to bring some of those plants, just some deeper rooted ones to suck up some water and help control the moisture in those damper areas."-**V8***

In one case a grower had taken a risk and stopped herbicide spraying under their vines and acknowledged that the impact of the under-vine growth on their property did not match what they

had feared would occur if the use of herbicides ceased. Stopping the use of herbicides allowed them to move towards achieving organic certification.

> *"If you spray this* [Herbicides] *you get all these invasive weeds coming in, and it's all thistles and all this rubbish. But if you actually stop that and go to a mowing situation, strangely enough, you end up with all these mowing resistant, drought resistant weeds that are naturally existing. If you count our sward we've got multiple species, but they're what naturally survive, but now we've stopped the sprayed-out strip it just seems that the low ground cover plants are actually dominating and taking over this strip. And it's been nowhere near as bad as what I imagined because when you stop spraying, you're not getting the big tall invasive stuff."-**V7***

Management Benefits and Consequences

The implementation of cover crops also provided some interviewees with a dilemma regarding the timing of management tasks. The sowing of cover crops co-incides with the end of the harvest period and the beginning of winter pruning. As a result, it is sometimes not possible for the growers to apply their annual cover crops, as it would mean cultivating between the rows during harvest.

> *"It's not just the money its actually the timing of it. One of the real problems In vineyards is that in the South Island the best time to plant is late autumn; even with grass, the farmers want a bit of rain and plant through in the winter. What's going on here in March and April? Everyone is harvesting. So you got this real clash of um what's going on as to what you want to do. So it becomes a real logistics exercise late mid-march is ideal planting time if conditions are right moisture in the soil and that sort of thing. 20th of march this [the vineyard] is still covered [in netting] and nearly ripe. you know it would be a huge task to try and then, even if you could plant it, you have machinery running up and down harvesting it, so it's a real challenge."-**V5***

An enabler for the implementation of the under-vine cover was the integration of new management techniques such as using under-vine weeders and "huckers" that allowed growers to manage their under-vine without the use of sprays.

> *"Our goal is to be herbicide free hopefully in about three years. So we're working on some project to, as an alternative to herbicides so it'll be organic weeder so we won't have any herbicides in the future under the vine"-**V03***

4.2 Shelterbelts and Hedgerows

Shelterbelts were a common feature in varying degrees in all of the vineyards due to the predominant nor-west wind in the region. One vineyard had also implemented a hedgerow of short native species along their east facing boundary. Shelterbelts here are the implementation of a row of woody trees to provide shelter. Hedgerows are a linear continuous mix of shorter woody shrubs or pruned trees that typically boarder the vineyard or boundary.

4.2.1 Location and Types

Shelterbelts were predominantly found along the Nor-West boundaries of the visited properties, many of these shelterbelts are inherited from the previous sheep-farming land use of the region. In addition to inherited shelterbelts, many of the viticulturists had also added to these structures with predominantly exotic species to further protect their vineyards from the damaging winds.

> "*A lot of those [Shelterbelts] were pre-existing on one of the blocks. We did plant Willows just like we planted Willows around here those Matsudana Willows (Salix matsudana) are like a shelter because there are bad winds."-**VWO1***

Some vineyards also placed hedgerows/shelterbelts between blocks of grapes within their vineyard as well as around some of their property boundaries to protect their vines from the wind (Figure 6). When used between vineyard blocks, the hedgerows/shelterbelts were typically located six to ten meters away from the first row of vines associated with each block.

> *"We put in shelter running east, toward yeah, north-south. And so we put it here parallel to the plantings that were all sort of facing, you know, due North so been north-south shelter. And we left six-metre gaps, but while upstairs [top terrace blocks] it has been manageable. It's a wee bit harder to contain the root intrusion. And we actually put East-West shelter across the other way, which is probably proven to be more valuable and less interfering and we inherited quite a few rows of pines."-**V7***

The species makeup of the majority of the hedgerow/shelterbelts were pine and poplar species along with mixed native species. Below are some typical examples of shelterbelts and hedgerows found in the participating vineyards (Figures 5-6).

Figure 5 Native species hedgerow (cabbage tree, harakeke, kanuka) along the access way and vineyard block boundary.

Figure 6 Inherited pine shelterbelt located between two vineyard blocks.

4.2.2 Ecosystem Service Provision

Ecosystem services recognised by participants in this study in relation to shelterbelts were; microclimate control, disease mitigation, biological control and aesthetic and cultural values.

Microclimate Control

Controlling the flow of wind and using shelterbelts and/or hedgerows to do so were the main ecosystem services that interviewees mentioned when first asked about what benefits they received

from their non-vine plantings. Waipara has regular strong nor-west wind that causes damage and stresses the vines in the region. Participants planted and retained shelterbelts to mitigate the impact caused by these winds.

> *"To try and get shelter to the vines, because we don't have a frost problem. So we can put trees in and so we're trying to negate horrific northwesters that particularly Sauvignon blanc is snapped all the shoots off and destroyed the vines and one year we had 50% of our shoots facing north just removed by the wind, but they were horrific hurricanes. Well, I haven't really seen it that bad since but you can get horrific winds here with the Northwest."-**V7***

One interviewee had used olive trees to provide shelter to his vines along with a pre-existing pine shelterbelt from previous land use (sheep farming). This interviewee was still adjusting and planning the non-vine vegetation on his property with the intent to have more control over the micro-climate of his vines.

> *"**How about the hedges? You said about the wind?** Yeah. Yeah, definitely. **Did you plant it on purpose?** Yep, still doing it and we picked everything. So the olive trees, they are currently key. So they are more of a bush habit than a tree. Yeah, we planted that because where this tree break finishes the north-west wind to comes down there and if we had tall trees, so just get flattened. Yeah. And also we didn't want them too big for the air movement from the south. So yeah, okay, but we still doing it still it's sort of ongoing."**-VO1***

Shelterbelts and hedgerows were the only structures that interviewees indicated that they were willing to invest resources into planning and designing for the specific purpose of receiving benefits. One interviewee had consulted a climatologist to advise on the placement of shelterbelts and mentioned that others would consult landscapers or take time to talk with other growers about designing shelterbelts through their properties to control airflow to mitigate both wind and frost.

> *"Yes the ones on the hill, we definitely planted them to help with the protection from wind."* ***-V2***

> *"You can't sort of go nuts. You just look at air circulation and stuff like that. Yeah, but you do proper planning consultant climatologists and a landscaper and consult local Growers and local knowledge. You can come up with a plan and keep modifying it"-**V7***

Disease Control

Along with controlling the strength of the wind in vineyard blocks and the movement of cold, frosty air, some vineyards are interested in controlling air movement for the control of botrytis. Botrytis thrives in humid conditions, as such viticulturists want to ensure good air movement around grape bunches to reduce the impact of botrytis on their crops. In some cases this meant removing some shelter to increase air movement.

> *"It can be detrimental in some stages. We have been moving shelter around the Riesling, to get rid of botrytis and with the new sort of powdery epidemic, so everyone's going for air circulation. So in some ways, we remove the poplars because of the root intrusion, you know? But still to get air movement, you know [there can be] too much humidity, too much shading. So in some ways removing this shelter is a benefit"-**V7***

Biological Control

One vineyard manager and son of the owners had recognised the benefit of cherry trees between grassed paddocks and vineyard blocks. He believed that the cherry trees were attracting the grass grub beetle and stopping it from getting into his vineyard, acting as a sacrificial crop. This was especially important for his management as they own an organic vineyard and do not have the option of using a spray during the day to control the grass grub on his property. No other vineyards were doing this, instead other producers opted to control grass grub with different spray options.

> *"Oh yeah an interesting non-vine planting that we've done is on a Driveway and you'll see that there are actually cherry trees lining all the way along one side. And that was all to do with grass grub, a little grub that then becomes a beetle that likes to eat grapevines."-**V1***

Aesthetic and Cultural Values

Another interviewee mentioned that along with providing a better environment for the vines, that the shelterbelts on his property also created a better environment for staff and that he thought this was why staff returned for more than one season.

> *"I reckon one of the biggest benefits is it just makes a lot more pleasant for people to work because especially in a howling southwest and north westers that are pretty normal in this area It's just so much nicer for the staff and I think that's the crucial thing actually."-**V3***

4.2.3 Ecosystem Disservice Provision

The ecosystem disservices associated with shelterbelts were negative impacts on microclimate and increased competition with vines and attraction of fruit-eating birds.

Negative Impacts on Microclimate

One vineyard owner mentioned specifically that they believed shelterbelts could cause shading on the vines and impact the vines ability to ripen.

> *"The trouble is it gives you shade as well so when the sun is low when the sun is low in Autumn, which is over there when you're trying to. Ripen at the end of the season, he's got a shelter belt shading his vines and he wont listen so."-**VO7***

Another disservice mentioned when talking about the presence of shelterbelts was the entrapment of frosty air and a possible increase in frost prevalence.

> *"But we can afford shelter because [we don't have that problem] but if you are a frost-prone area they are really terrified about frost."-**V7***

> *"We can have a look around you'll see what I mean about areas we could potentially plant just with the negative side like we touched on the frost and sheep."-**V8***

Some growers had the belief that removing the lower sections of their shelterbelts, creating a gap for air to flow through. This mitigated the impact that frost could have on their block by allowing for air movement. This difference in understanding of the GI components is a barrier for implementation.

> *"we have we have frost problems. We have kind of remove, remove the bottom branches that a lot of shelterbelts.. So the air can get through but yeah, that's another Factor. Yeah, but we'll just deal with that. Like we're not getting rid of the trees Yeah, that's that"-**V3***

Increased Competition with Vines

Shelterbelts close to vineyard blocks also caused some concern to interviewees as they reported that there was increased competition close to the trees.

> *"I can show you there are lots of problems with root intrusion and competition."-**VO7***

*"They like probably the first two or three rows of vines, always a lot weaker because of those trees and just the nutrients at those trees suck out of the ground and the water and everything like that those vines tend not to crop anywhere near what the rest of the block does."-**VW1***

Increased Bird Populations

Interviewees were concerned about bird populations in the area and included the netting of rows as part of their vineyard management practice. It was believed that shelterbelts provided roosting habitat for the bird species that predated on the grapes.

*"Starlings are just crazy around here. Especially that time of the year they just flock. The native birds aren't as much of an issue for us. The little wax eyes the thrushes Blackbirds all of those other ones that come in, in bigger numbers and cause damage. yeah. I guess its a pity."-**VW1***

*"Birds would be the main issue [*from shelterbelts*]."-**V2***

*"Yeah, starlings. They do a clean job. They come in a big mass, so they can do a lot of damage, it takes a whole berry."-**V7***

4.2.4 Enablers and Barriers to Implementing Shelterbelts

The enablers identified from the interviews for the implementation of shelterbelts are: recognition of the need for the ecosystem services shelterbelts can provide; conversely the recognition or belief that a dis-service may occur is a barrier for implementation. Access to knowledge regarding how to implement and design shelterbelts in the vineyard for maximum service provision (and minimal disservice) is also an enabler for shelterbelt implementation. The challenges in terms of vineyard management is also a barrier for the implementation of shelterbelts in vineyards.

Potential for Ecosystem Service and Disservice Provision

Perceived ecosystem services associated with hedgerows and shelterbelts acted as an enabler for their implementation. However, some vineyards recognised possible ecosystem dis-services and so had removed shelterbelts or decided not to implement them on their properties.

Many interviewees expressed that they avoided planting due to concerns around frost.

> *"We have avoided planting extra trees to date along most of the boundaries. Frost is an issue. We don't have Frost protection we rely on the slope and the airflow and to provide that so the more hedges you put up the more it restricts the airflow on your property. So that's an issue. Let's say we planted a macrocarpa hedge or something along that boundary ... well you … might have advantages [that] might increase; … you might be able to reduce summer nor wester effects, but ... when … [it] comes to bud burst you're increasing your risk of frost, so we avoided doing that."-**VO2***

Conversely, some growers had the belief that removing the lower sections of their shelterbelts mitigated the impact that frost could have on their block by allowing for air movement.

Management Benefits and Consequences

Some interviewees were concerned about the impact that hedgerows or shelterbelts would have on vineyard activities and the maintenance that they require such as trimming.

> *"We haven't actually got any (shelterbelts). Everything is used and even the areas that I would at the moment I wouldn't because we have to get into those areas to trim trees."-**V3***

> *"We're gonna try to remove half of them (shelterbelts) this year, because they're just getting really big and problematic and they're expensive to prune."-**V7***

One vineyard had removed shelterbelts when they were planting their vines to allow for maximum space for vines to be planted while still allowing for turning room for equipment.

> *"Your main aim was to maximize, you know, get as many vines as you could onto the property because that was the original intent, only leave enough turning room for equipment and plant the rest, to vines"-**VWO1***

Access to Implementation Knowledge

When asked if there was anywhere that growers would consider putting in more shelterbelts, some growers expressed that they were concerned about shading, air movement and competition with the vines. One grower expressed that he did not know at which distance this competition would occur and that he would like to have a general figure regarding this.

"***Would that be the next place you'd be thinking about putting in plants? Is there anywhere?*** *I doubt it, but I think what vineyards are conscious about is they don't want the natives too close because they might not get the fruit ripe due to shading. It would be good to find out the distance between plantings and trees, a general figure. "-****VO1***

4.3 Nature Conservation and Insectary Habitats

Nature conservation and insectary habitats are identified here as areas with woody or herbaceous species planted or existing within close proximity of each other. This includes native plantings planted for conservation purposes both privately and through the Greening of Waipara Project, exotic species and regenerating patches such as those typically located in gullies. These fit into the patch and corridor category of landscape structure theory. The crops, grass, gardens, and other low growing vegetation between is termed the 'matrix'. Patches are discrete resource-rich areas, that can provide steppingstones, and corridors continuous linear pathways, through the landscape for wildlife – big and small.

4.3.1 Location and Types

Patches of native plantings or native insectary patches were generally located away from vineyard blocks in areas unsuitable for grape production, either because of the lay of the land or the soils/topography for grape production or close to cellar door areas. Having plantings in areas where visitors to the vineyard will see them was of a high priority to many of the interviewee's especially with native planting patches. It was for this reason that many of the vineyards with cellar doors planted their Greening Waipara biodiversity trails or patches to be accessible via their cellar doors or entranceways.

*"Basically where it's visible. So, I don't know if you noticed when you came in on the right-hand side. There's a bank that we've planted up and natives, so that's because when people come up on the cycle trail. It's just a nice sort of entrance to the vineyard. The Greening Waipara plantings are at X (*their other vineyard block*) because we did have a cellar door but now it's because it's (*Their cellar door*) all shifted over here."-****V2***

*"The Greening Waipara plants were along the drive coming"-****VO3***

However, some vineyards mostly those without cellar door selected areas next to pre-existing indigenous habitat for their plantings, in two cases these areas were also adjacent to the vines such as Figures 7 and 13 below.

> *"We got involved with Greening Waipara in the very early days and I have a planting on top of the hill. I felt there's a matagouri stand up there and it's on our side of the fence right next to the matagouri." -**VO7***

Figure 7 Greening Waipara planting located next to pre-existing natives (matagouri and pohuehue) and adjacent to the vineyard.

When asked about where plantings will be implemented in the future, responses generally included areas that were out of the way of production activities or close to areas that have visitation from the public. The majority of interviewees wanted plantings to be away from the vineyard blocks.

> *"Generally, the plantings that we will do will be sort of out of the vineyard or a place that's easy to fence around and aren't kind of in the middle of the vineyard"-**V2***

However, one vineyard manager stood out in his efforts to integrate native plantings into the vineyard. They had trialled planting native species at the end of their rows that were within sight of the cellar door and restaurant.

*"'I've been trying to introduce some diversity in the vineyard and this is a typical block here and it was especially for people to see, so it's Maori Jasmin, at the start of those rows."-**V4***

Because all of the vineyards interviewed were involved with the Greening Waipara Project most had one or more patches of native plantings located on their property, some plantings had perished in droughts. These patches consisted of locally sourced natives and many plantings were fenced off from the rest of the property. Three of the properties also had biodiversity trails that were all close to the cellar door. Biodiversity trails featured the locally sourced natives, a pathway through the plantings, structures for lizards, and signs providing information on the plants and structures used. Figures 8- 9 below contain pictures of the biodiversity trails visited during this study.

Figure 8 Biodiversity trail attached to the cellar door and vineyard block showing the native under-vine plantings and native end post plantings.

Figure 9 One of three biodiversity trails attached to the cellar door and adjacent to the vineyard block with locally sourced natives planted.

Gullies were also a common feature on many of the vineyard properties. Some gullies were left unmanaged with naturally occurring scrub species such as matagouri and NZ broom grew in these areas (Figures 10-11).

> *"And then we've just got this gully there runs through the middle of X and that's just left to do what it wants"-**V2***

Figure 10 Gully with vineyard behind with regenerating scrub species.

Figure 11 Gully with stream next to vineyard blocks with unmanaged native and exotic species.

Other interviewees had gullies that had been planted with exotic species such as pines with the intention of harvesting these for timber (Figure 12). One property had fenced off part of the gully on their farm and used the area for both timber and keeping deer.

"The pine trees that are planted down in the gully were originally planted as sort of like for money basically they export quality logs, but they have created a really nice microclimate."- **VW1**

Figure 12 Gully with pines originally planted for timber.

Most vineyards had identified their gullies as areas for potential planting zones, especially for natives.

*"So there's another reason why a lot of vineyards don't like trees unfortunately you know if they are up a gully or away from the vineyard perfect." -**V8***

Vineyards also had implemented or retained patches of plantings along gullies. These plantings were mixes of native and exotic species, although plantings that were recently planted consisted of natives.

*"We've planted along the gulley with the stream that runs through both properties of native plants just to try."-**V2***

The gullies that had been planted with natives or a mix of species were located between or adjacent to vineyard blocks. Figures 13 and 14 show two examples of native plantings alongside vineyard blocks. Figure 13 was a part of the Greening Waipara scheme.

> *"My personal involvement in the Greening Waipara was this little gully here and that little one there and you can walk down and have a look; there's another one beyond that. You can see the natives as a big part of it (figure 13)"*-**V5**

Figure 13 A series of greening Waipara native plantings in a gully running through vineyard

Figure 14 Terrace (gully) bank planted in natives adjacent to a vineyard block.

4.3.2 Ecosystem Service Provision

Ecosystem services recognised by participants in this study in relation to nature conservation and insectary habitats were erosion mitigation and aesthetic and cultural values.

Erosion Mitigation

Control of soil erosion was a service that vineyard owners and managers were receiving and using from the green infrastructure that was present on their properties. One vineyard had noted that they had an erosion problem on a hillside and intentionally planted poplar poles to mitigate the effects.

> *"we've done a few plantings of up on the hillside to control erosion, but they're not really natives are like the popular poles. We have done those up on the hillside. You can kind of see it just on the hill through there. They're just like individual poplars. Yeah, so they just plant them out and just to stop the soils eroding"–**V2***

Aesthetic and Cultural Values

When asked about why plantings were planted in their location a common answer was because it added to the aesthetic values of the vineyard and cellar door rather than for environmental reasons, especially if the plants were exotic.

> *"I don't really know originally why these trees were planted but we've got quite a few Chinese Elms in this sort of area down here which, which I guess a lot of it is more for aesthetics than for beneficial to the environment sort of sort of thing I suppose. And the same with the poplars up and down the driveway"-**VW1***

> *"There's a bank that we've planted up with natives and so that's because when people come up on the cycle trail. It's just a nice sort of entrance to the vineyard. The Greening Waipara plantings are at X [their other vineyard block] because we did have a cellar door but now it's because it's [their cellar door] all shifted over here."-**V2***

4.3.3 Enablers and Barriers to Implementing Nature Conservation and Insectary Habitats

The enablers identified from the interviews for the implementation of nature conservation and insectary patches are: recognition of and need for the ecosystem services that nature conservation and insectary habits can provide, conversely the recognition or belief that a dis-service may occur is a barrier for implementation. Access to knowledge, regarding how to implement and design nature conservation and insectary habitats in the vineyard for maximum service provision, is a barrier for implementation. The challenges in terms of vineyard management is a barrier for the implementation of nature conservation and insectary habitats. Access to and presence of funding is an enabler for many interviewees. Commitment to the implementation and upkeep of nature conservation and insectary habitats is both an enabler and barrier, this was dependent on the culture and beliefs in each vineyard visited.

Potential for Ecosystem Service and Disservice Provision

When faced with an ecological problem such as erosion some vineyards used non-vine plantings to mitigate their impact on the environment. An example of this was the use of poplar poles on a

hillside that was being impacted by the previous land-use (sheep farming) on one of the vineyards (Figure 15). This vineyard contacted the local nursery and asked for advice on what to plant to mitigate the erosion that was occurring on their property. The identification of the need for ecosystem service provision resulted in the implementation of this green infrastructure component, showing that if growers perceive a need for an ecosystem service they will seek out information on how best to implement the green infrastructure to achieve maximum benefit.

Figure 15 Poplar poles used to mitigate the effects of erosion.

Management Benefits and Consequences

Another barrier for the implementation of conservation and insectary habitats, particularly natives, was the establishment period and additional management care that may be required. Although locally sourced natives are commonly used in plantings and assistance is sometimes gained from the local nursery. Many interviewees reflected on the time it took for plantings to become established and that they needed to be irrigated or watered during this period especially in the dry summers that Waipara experiences due to its pravailing north-west wind.

*"The most common problem when people plant a whole lot of the natives is maintaining them in the busy season you know, the summer starts to get dry and you get busy and forget to water them and then you forget to weed them. Yeah, and then they don't all grow and rabbits eat them and you lose them. So yeah, that's the hardest thing when you plant them that you've got to be able to maintain them as you go."-**V6***

*"You have to water at all and it would take a bit to establish." -**V2***

*"But we've got a bit of irrigation here. So, we can get these off to a start and just see how it goes."-**VO2***

One vineyard noted that a lack of maintenance and irrigation was the reason that some of their non-vine planting efforts had failed, as they did not have the time during that part of the year to tend to the native plantings that they had put in.

*"We did [*irrigate], *but the sites that we planted on had fairly high winds that none of it has survived really there's only a very few of the things that have survived."–**VO5***

Figure 16 Biodiversity trail planted in 2008 in a state of disrepair.

Some of the biodiversity trails that were implemented during the Greening Waipara project still needed tending to if they were to be kept for their original purpose. Figure 16 above shows an example of one of the biodiversity trails planting in 2008 that was connected to the cellar door experience. The grower acknowledged that not many people use it anymore and that it needed some tending to restore it and make it more attractive for guests.

The timing of planting of the native patches was also of concern to some interviewees, as they had been recommended to plant during spring, a time when the interviewees are very time-poor.

> *"And there's always an argument the guys at Lincoln want it done in spring and we would do it now (*Autumn-June*)."* -***V4***

Properties with land unsuitable for grapes such as gullies, low-lying areas, waterways and oddly shaped areas were recognised as suitable areas for planting or had already been planted through their own volition or via the Greening Waipara Scheme.

> *"Yeah. We've planted up a sort of along the galleys in the Stream that runs through both properties of native plants just to try. I think when they first came on to [*their property*] and particular the stream was really overcrowded."-**V2***

> *"We just have to generally the plantings that we will do will be. A sort of out of the vineyard or a place that's easy to fence around and they aren't kind of in the middle of the vineyard."-**V2***

Access to Implementation Knowledge

When interviewees were asked about whether or not their plantings created a system within their vineyard or throughout the region, many of the interviewees seemed unaware of this concept and how it could provide benefits to them. A few had heard of the landscape structure/dynamics concept. One of these came from a horticultural background rather than viewing himself as a viticulturist, and displayed a good understanding.

> *"Yeah. I want to start linking the blobs of natives that we have around the place and I want to enhance the banks. But I'm looking at quite a large program."-**V7***

Later on in the interview, this individual also mentioned how the neighbours sprayed their land and indicated that this was affecting the surrounding landscape corridor integrity. He seemed to show a greater understanding of how the plantings interacted within the system.

> *"**So does that impact how your natives kind of grow**? Not really? No. I suppose it ruins the corridor effect when people stop blowing out every Gully on their property like happened next door and they start bringing helicopters in and obsessing about weeds on unproductive hillsides."-**V7***

Another individual was also aware of how the presence of corridors could provide habitat and movement of native species throughout the region. This knowledge played a large role in his planning and development of their plantings.

> *"Yeah, but the Greening Waipara tried to create a bit of corridors coz yeah. Up here they have proven, its documented that there's native bush up on the hill and we wanted to connect the Greening Waipara with those to get the wood pigeons down into the valley." -**VO7***

While those interviewees with less conviction around creating connected plantings responded to this question with either another question or using a vague response.

> *"Would interact? for sure."-**VW1***

> *"Hmm to like to connect the non-vine planting? Yeah. Well, I guess the one big non-vine planting is the Olive Grove, there's is two thousand trees there."-**V1***

> *"Yeah, that's what Jamie would do or what Colin and Steve did, they had smaller ones and bigger ones."-**V4***

Many vineyards indicated that they knew who to contact for assistance and vineyards were proactive in communicating to each other who they had talked to about establishing native plantings. The main resource for assistance was the local nursery, which was pivotal for the implementation of many of the green infrastructure components on the properties, especially natives. The local nursery provides information on what to plant, local sourcing and the locations on the properties that would make for better planting sites for the maximum establishment of the plants purchased.

*"**Do you think you'll ask him for advice or get him to come out?** Definitely yeah, he's the expert." –**V6***

*"**How did you choose the species?** Jamie did that for me, two things I get him to do is choose what's suitable and lay them out. But we always talk about the best time to plant them." –**V5***

This assistance and knowledge provided to the growers is important as locally sourced natives allow for the integration of the natives to the planting site to be more effective and allow for lower levels of subsequent management of the plantings. It was also mentioned that they felt comfortable approaching SWNZ (Sustainable Winegrowers New Zealand) for advice around planting natives and available funding.

*"If we were going to talk to anybody, I'd probably call SWNZ first because I mean they would be able to point you in the right direction, but I'd also talk to them, that's who I was going to talk to when we were talking about planting around the shed."-**VW1***

The knowledge provided by the Greening Waipara Project was an enabler for the implementation of native patches within the vineyards. This assistance consisted of knowledge regarding the correct plant species, the timing of implementation, and providing emphasis on the value of biodiversity and ecosystem services that benefit the vineyard.

"**Greening Waipara expertise was really great they did some funding which was excellent and the knowledge of the right plants what to plant way to plant and had a plant and the timing and placing a real value on it. They were talking a lot about diversity and natural predators all of those I think resonated really well, but farmers in Waipara are very time poor, it's not an excuse it's just a reality that a lot of us are just under the pump anyway so having the expertise available was really good."-**VO4

Access to Funding

Some interviewee's had proactively sought funding from different organisations to get locally sourced natives for planting. Most vineyards mentioned the Greening Waipara scheme funding and or assistance that they had received. However, they weren't sure exactly what financial assistance they received, possibly because it was ten years prior to the interview.

*"Even with all the stuff we did way back, Steve [*Greening Waipara] *got the grants to do research work, but we bought the plants. Yeah, we didn't get any, we got labour. He brought out students."-**VO1***

*"**Have you applied for any recently?** No, I mean not since sort of Greening Waipara I think it's under promotions now, who does it all." -**VO1***

*"I don't know, do Land-Care do it? Possibly they used to do stuff [*receive funding] *with the Greening of Waipara."-**V6***

*"We haven't sort of sorted out any funding in recent times other than that Greening Waipara."-**VO2***

For some vineyards, when asked if they had received any funding or were aware of any funding available, did not know about any funding or assistance that they had received in the past or could receive and indicated that they had not tried to apply for funding or assistance. Some, however, indicated that despite not knowing what was available to them, that when the time comes, they will apply or put their hand out for assistance.

*"No, I'm not aware of any because I haven't looked at it."-**V8***

*"There are different schemes in the likes of ECan boards (*local council*) in the area I haven't been looking forward to this date, but there are some funding."-**V4***

*"It might be something we look into it more in the future. If we wanted to get a decent amount of plantings in."-**VO2***

*"When we go to raise some funding, I'll put my hand out, and I would love some when we want planting around there."-**V09***

*"No, but you know, I think it's just it's just like waiting really waiting for something to be done."-**V3***

Of those interviewees that had applied for funding, they indicated that the process had not been onerous or tedious and that their efforts had been successful. Some interviewee's that had been successful in applying indicated that they would not apply again as they received it the year prior and

would think it unfair. This indicated a level of self-regulating to ensure that the funding available might be shared throughout the region.

> *"Yeah, last year the Hurunui biodiversity fund gave me $500. I won't apply again because I got it last year and I think I probably deserve it because we do a good job and do what we say we're going to do but yeah I won't apply again at the moment.* ***How was the applying process? Did it take a long time or?*** *No, no, I think I downloaded the forms and did it in an hour or 2 Yeah, I think Jake helped me and we gave them some photos and stuff like that and a bit of mapping. Yeah, but, it wasn't too bad."-****V7***

Some funding options in the region where only available if the area being planted was a public area. The cycle trail that runs through or past 12 vineyards in the region, five of which were involved in this study meant that two of the interviewees had been successful in receiving seedlings from Trees for Canterbury as the area they planted was in relation to the cycle trail.

> *"****How do you find that applying process was?*** *I got 150 plants from Trees for Canterbury, and they have another funding thing in August that was mainly for the cycle one I just said, well its private but its open to the public."-****VO7***

> *"We either use Trees of Canterbury or Alex who's our staff member there likes to plant. He sources seed locally and also Hurunui natives they outsourced locally as well."-****V2***

For larger companies, access to funding from their own budgets was an enabling factor they seemed happier to do this than take funding away from smaller businesses. Conversely, the lack of funding set aside for greening in larger corporate companies was a barrier for the implementation for the continuation of greening. This lack of budget was due to the vineyard manager being expected to run the property for maximum yield for shareholders with no funding for cover crops, under-vine planting, end-post plantings or conservation habitats allocated within the management budget.

> *"We also have some money in the budget to plant some more native areas next year. I'd ask to get money out of my own budget first. Yeah, I'm pretty sure I could each year get some, but if I couldn't yeah, I would certainly try and get something from somewhere else. That would be quite good."-****V6***

*"We are big enough we should do it ourselves. As my theory we should leave the funding for those who can't afford it, you know our size we should."-**V8***

*"Yeah, so it's not a smaller, you know private Vineyard where you decide to yourself. It's a lot of people to deal with and to go and do to change things. And as a larger group, so far they haven't been so much interested in organic and it's just more like at the end of the day, I think the shareholder want some, you know, to make sure it does make some money back. So what we have, you know invested in the past in Greening Waipara, we haven't really developed any further because I haven't got really any money or resource to do that."-**V4***

This last quote from a large company with no investment in greening suggests another barrier is also present within the greater theme of funding available. The interviewee indicated that smaller properties may have more freedom with their budgets and time to allocate and apply for funds. Whereas larger company vineyard managers are under more pressure to run the vineyard in accordance to a more conventional high production high profit model. This is a theme that could be explored further as this study only included three large corporate styled businesses, two of which had funding available for plantings around offices and on unusable land.

Level of Commitment

Two of the vineyards had access to their own seedlings for the planting of native patches and insectaries. This access was through a private nursery run by the vineyard manager and one staff member having an interest in raising his own seedlings for the vineyard that he worked on. These two individuals displayed behaviour that suggests they are personally invested in implementing plantings and both act as enabling factors within their vineyard systems.

*"It [*the nursery] *was still a bit under construction but I've got a wee mini nursery and we've built a propagator and we just finished vintage and were about to start filling it up. We are going to run a nursery and grow our own natives. To plant these areas and that's a bit of a goal."-**V7***

*"This is one of the little pockets that Alex has planted just on the corner here it was just one of those out of way; and these would all be plants from his little garden where he grows seedlings, so if we let him he would do that all day long."-**V2***

Some interviewee's appeared to be ambivalent and non-committal about the areas that they could possibly plant or where they planned to plant. These responses indicated a lower level of commitment or enthusiasm for the implementation of non-vine planting within their systems. The interviewee who provided the following quote was also sceptical regarding the benefits that they could receive from non-vine plantings. This individual's level of enthusiasm could be related to their level of education and personal beliefs regarding the benefits of implementing green infrastructure in their vineyards.

> ***"Do you have any areas like that still that you'd think about planting there anywhere else?*** *Possibly Yeah.* ***Or do you know of any other areas?*** *Possibily."-****VWO1***

One interviewee pointed out that a reason many growers don't plant non-vine plantings is due to the fact that they are time-poor. He thought that the Greening Waipara project was successful, as it provided growers with the resources and education surrounding the benefits that they could receive if they implemented more GI. However, this statement was contradicted by one grower who believed that if they wanted to plant non-vine plantings that they would find the time to do so.

> *"They were talking a lot about diversity and natural predators all of those I think resonated really well but farmers are very time poor it's not an excuse it's just a reality that a lot of us are just under the pump anyway so having the expertise available was really good."-****VO4***
>
> *"But it would do more it would be more your marketing and your philosophical bend you'll either do it or you won't do it."-****VWO1***

Some interviewees also held strong personal beliefs or personal ethos that could act as barriers to the implementation of green infrastructure in their vineyards. For example, that GI is impractical and that as viticulturists, they should focus solely on the production area, this meant they did not view their whole farm system.

> *"You know you got a wish list and then there's a practical list. Sometimes the practical list is fairly important."-****VWO1***

*"**You've got all these opportunities**. Yeah, I've got viticulture to think about it (*greening) *doesn't enter my mind too often."**-V3***

4.4 Waterways and Ponds

Water patches and corridors refer to the areas on the vineyard that are associated with ponds, dams, drainage ditches, and streams that run through some vineyards throughout Waipara. Many of these areas have plant species associated with them both intentionally and unintentionally while irrigation dams tended to be unplanted.

4.4.1 Location and Types

Many of the vineyards interviewed had bodies of water or waterways within their vineyard systems such as streams, ditches, ponds, dams, galleries and rivers. Vineyards without these water systems were using water from bores on their properties or water from an irrigation scheme. Interviewee's streams were generally planted with natives and streams without plantings had self-seeding willows along the stream banks, the willows tended to require management to keep the streams clear (Figures 17-18).

*"I think when they first came on to X and particularly the stream was really overcrowded with Willow so they cut all that out and replaced it with native plants that aren't taking over the stream so much."-**V2***

Figure 17 Stream running along the periphery of a vineyard with self-seeded willow species

Figure 18 Stream running along the boundary of vineyard property with natives planted by the vineyard owner.

Ditches on vineyard properties were not commonly planted. Ditches consisted of grassed verges with occasional scrubby species such as Matagouri and some planted tree species. When asked about what water systems that were present on their properties, the interviewees did not mention ditches until directly asked and were not enthusiastic about planting banks of drainage ditches (Figure 19).

> *"We talked about planting something through here* (the drainage ditch) *but we don't want to be too close to the banks cause we need to clean them out now and again just to keep the water flowing."* -***V8***

Figure 19 Unplanted ditch between two vineyard blocks.

Three of the four ponds were adjacent to vineyards while the most planted pond was located away from the properties vineyard and was located within sight of the cycle trail that runs through the region.

> *"You'll see down there we've got a series of ponds (Figure 20) and so they (previous owners) planted natives around one of them I mean it's just those ponds are basically overflow from our bore that we have, we have for the irrigation. We don't use it anymore."*-***VW1***

Figure 20 Pond away from the vineyard in view of cycle trail with extensive native plantings.

Figure 21 Pond system adjacent to the vineyard block.

Dams were also located on many of the vineyard properties, they were generally unplanted but a few had a reed species growing around the banked areas. One vineyard had made an effort to plant around their dam but the plantings had not persisted.

> "That's *the dam. We did plant. I planted a few natives on this top bank. There's only a cabbage tree remaining."*-***V2***

Figure 23 below was a dam set up for frost fighting in the surrounding vineyard blocks, due to the pump system the water needed to remain free from foreign bodies.

> *"We have got the dam when you came in that we put in for frost fighting it's and we can irrigate from it if we have to But it's primarily set up for frost fighting.* ***Are any of your water systems planted****? No, up there you have the pump and frost protection so the water needs to be clean."*-***V8***

Figure 22 Vineyard dam for irrigation with a few reed species (rushes)growing and grassed banks.

Figure 23 Dam for frost fighting with a fenced mown grass exterior

One vineyard interviewed had what they called a gallery this was a series of two ponds that were embedded into the gravels associated with the river that ran past their property. At the time of the interview, this was unplanted and had a mixture of grass and weed species along the banks of the gallery ponds (Figure 24). The interviewee planned to plant this area using plants from his own nursery.

> *"So we have what we called a gallery. It's basically a pond dug into the river gravels. Yeah, that's not directly connected to the river. It's technically hydraulically connected to the river but was taken from a vast body of water traveling through the gravels. We're about to start filling it up and we are going to run a nursery and grow our own natives. To plant these areas." –**V7***

Figure 24 Gallery ponds with grass and weed species on the banks.

Two of the vineyards interviewed also had rivers running through their properties. Neither vineyard had implemented plantings in these areas, but both properties had some pre-existing species. These pre-existing species were predominantly willow and scrub species that have self-seeded via the river system. These species had caused some management challenges due to their large numbers and competitive life cycle.

> *"The gorse and broom. Yeah, like the time we remove everything out of the riverbed and then we put a fence in there but at all just grew again."-**V7***

4.4.2 Ecosystem Service Provision

The ecosystem services recognised by participants in this study in relation to waterways and ponds were: water quality control and aesthetic and cultural values.

Water Quality

Interviewees mentioned water quality and treatment of winery wastewater as a service that they were receiving or had received in the past. One vineyard had inherited a pond system when they

purchased the vineyard manager/winemaker recognised the value of that ecosystem for the quality of the water but did not think it was benefitting his vines due to the plantings being too far away.

> *"Border waterways down there. It's definitely for the ecosystem. There's a lot of beneficial things you can get from having that sort of area plants at especially in a winery sense we can be seen as sometimes a little bit sort of evil in the environmental perspective…I don't think they had any thought of whether they would be beneficial but definitely beneficial for the water system. Yeah. Through all the filtering all that sort of stuff but for the vines, I don't think there was much but because the next pond down is quite a bit closer to the vines"-**VW1***

Another vineyard that no longer processes their grapes on-site had a remnant area of flaxes that were planted for the purpose of soaking up excess water.

> *"So it was actually put in so the wastewater would go down in here; it went through the treatment thing and you and will pump down there, obviously you can't just pump water out to nowhere you have to use something to soak it up, so that was put in for that."-**V6***

Aesthetic and Cultural Values

One of the vineyards had identified the river section of their property for a potential walkway for visitors that visit their cellar door and intended to plant this area as a part of their long-term goal to increase the amount of biodiversity they currently had on their property.

> *"I think yeah, but we can create such an experience for people to go to walk down there and things will be ideal. Yeah, a trail maybe? Going from here all the way down to the riverbed and planting along the riverbed that should be a grand plan. So, the idea might be that we obviously go down there and then we could have a track and then right along the riverbed do a sort of circuit right round back up to like, the to the vineyard on the corner there."-**VO1***

4.4.3 Enablers and Barriers to Implementing Waterway and Pond Plantings

The enablers identified from the interviews for the implementation of waterways and ponds was level of commitment.

Commitment

One interviewee was interested in planting his streams as he liked natives and the concept of fencing off waterways as he had an appreciation for conserving wetlands and the local natives from the

surrounding area. This interviewee also allowed his BnB guests to visit his plantings along the stream and join onto the cycle trail.

> *"I've always quite like Natives you know the concept of fencing your waterways. And so I've done this and Stages this waterway was open to the cattle and everything for well hasn't been for the last sort of six years, using the local plants too."-**VO8***

4.5 Landscaped plantings

The term landscaped plantings refers to plantings of native and exotic species located around buildings and entranceways.

4.5.1 Location and Types

Landscaped plantings were located around cellar doors, entrance/accessways and around work sheds/office areas, these areas have been planted primarily for aesthetic purposes. Cellar doors had open areas of mown grass that often looked out onto the vineyards with areas of the garden with mixed exotic and native species (Figures 25-27). However, some vineyards had tried to make these areas predominantly natives especially when the Greening Waipara biodiversity trail was close to their cellar door. When asked about what non-vine plantings were present on their properties, many interviewee's did not mention their cellar door plantings initially and needed to be prompted regarding what features were present.

Figure 25 Cellar door gardens with native species.

Figure 26 View of events lawn and vineyard from seating by the cellar door with native NZ jasmine on the end posts to the left.

Figure 27 Cellar door entrance with mixed native and exotic species.

The images above all have a common factor of an area of nicely mown, highly manicured grass which is usually quite a large area. When one interviewee was asked about his cellar door area and the

amount of nicely mown grass, he indicated that the area was used as a part of the cellar door experience.

> *"**Now this area here in front of us isn't planted, why is that?** Yeah, but well, sometimes we'll have people here drinking and milling around."-**VWO1***

Another highly landscaped area in vineyards was the entrance/access ways. Accessways were often landscaped with native and exotic species. This area of planting was generally recognised during the interview's but often only mentioned in passing - didn't go into what they had planted.

> *"**What non-vine plantings do you have on your property?** We've just got like a drive and a couple around the shed." -**V8***

However, from what was typically observed (Figures 28-29), entrance-ways and driveways were planted with a majority of native species and were often adjacent to vineyard blocks.

Figure 28 Driveway with natives planted adjacent to vineyard blocks.

Figure 29 Entranceway with mixed native and exotic species away from vineyard blocks.

Other landscaped areas were around work sheds and office related buildings. When asked about what non-vine planting they had on their properties or where they were planning on planting, a few interviewees mainly those without cellar doors mentioned the plantings they had around their offices or work-related building such as sheds.

> *"Last year we planted a lot more plants around the area here of the office and sheds (*Figure 31*) and the yard, but we also have some money in the budget to plant some more native areas next year. So I am in big favour of the biodiversity of plants to you know. So there was talk about planting natives and grasses and stuff like that around the shed, but we're just sort of waiting for everything to settle because it was only a year ago."* –**V6**

Figure 30 Patch of natives adjacent to vineyard and surrounding vineyard office.

Figure 31 Offices with exotic and native plantings adjacent to vineyard blocks.

4.5.2 Ecosystem Services

The ecosystem service that was recognised by participants, in relation to landscaped plantings was aesthetic and cultural values.

Aesthetic and Cultural

Vineyards that had cellar doors, residential or work-related areas that received guests had non-vine planting to provide aesthetic services. When asked about what benefits they received from their

plantings, many interviewees replied with an answer that included the visual improvement of their environment.

> *"Hum no, we just did initially we just did some plantings just but beautification basically just define areas a bit more and those kinds of things."-**V1***

> *"I think just even from a visual aspect for people coming, like visitors coming through the vineyards. They see that it's not just a monoculture."-**V2***

When asked about why plantings were planted in their location, a common answer was because it looked good rather than for environmental reasons, especially if the plants were exotic.

> *"I don't really know originally why these trees were planted, but we've got quite a few Chinese Elms in this sort of area down here which, which I guess a lot of it is more for aesthetics than for beneficial to the environment sort of thing I suppose. And the same with the poplars up and down the driveway."-**VW1***

Two vineyards mentioned that they had contracted an architect to design plantings and outdoor spaces around their cellar doors; both vineyards were looking for aesthetic values from these areas.

> ***"When you approached the landscape architect, did you have any other benefits and mind from the plantings that you wanted?** No, I think that was really just aesthetics back then because that was pretty early on and then I think that landscape architect gave a bit of a scale for us just of practicalities of space between the buildings and things like that, for turning and all that sort of thing, but it was all very general."-**V1***

> *"Well, the little bit of garden in there and we had a friend come in and she, she designed that.**"-VWO1***

While other interviewees had not contracted landscapers to design their cellar door plantings, they had put more thought and planning into these spaces and were able to outline their plans for the space in detail. They recognised that these spaces had more value than the biodiversity trails that were also located on their properties and that they could provide crops for the cellar door.

"So the car parks going to have palm trees through it and citrus yeah, so we can pick citrus out of it. So I'm going to have zones of a grapefruit, might do some dessert figs. So we are putting a food garden in and to connected with the winery restaurant side of it." ***-V7***

"I shouldn't be offended that not everyone wants to do the walkway. And I don't know if it brings many people in but we did see it a value, but we thought we were probably better off putting a concentrated effort into the garden where people can sit and drink wine rather than more walkway planting." ***-V7***

Some interviewees also recognised that the services that they were expecting to have present on their properties were beneficial to the environment and the community. They pointed out that this should be appreciated more to encourage better stewardship of the land.

"I think these are social services or environmental services that society more broadly needs to appreciate more, and we need to understand that if you want someone to provide good stewardship of their land, they need help, you know?"- ***VO2***

4.5.3 Enablers and Barriers to Implementing Landscaped Plantings

The enablers identified from the interviews for the implementation of landscaped plantings was the potential for aesthetic and cultural ecosystem service provision.

Potential for Ecosystem Service and Disservice Provision

An enabler for the implementation of landscaped plantings was the gaining of aesthetic/cultural value for visitors to the vineyard. When asked if they believed that the biodiversity trail brings visitors to their properties, one interviewee expressed that he thought the gardens surrounding the cellar door played a larger role in attracting visitors to their vineyard.

"Like about one-fifth of the people do the walkway that we've developed which overlooks the Vineyards and starts with native plantings, and I'm not really too sure if it actually draws anyone in. A fifth of the people are interested to go on the walk. Probably greater value to us are these gardens here that we've put in because people can sit and probably it is quite good that lots of people come to taste the wine. And there's the primary interest in that and is probably where it should be and they like sitting in the garden."- ***V7***

Although this interviewee believed that the cellar door garden had more value for attracting customers, they still commented that they would continue to plant elsewhere as they wanted to do that for themselves anyway.

4.6 Additional Enablers and Barriers for Implementing Green Infrastructure in Vineyards

Three additional enablers and barriers were also identified during the interviews. However, these cannot be referred to in regards to individual green infrastructure components but rather to the implementation of green infrastructure in general, as they are related to how GI is viewed, designed and enforced as a whole concept. These enablers and barriers are the prioritisation of land, certification requirements and enforcement and marketing value. The evidence for these enablers and barriers is explored below.

4.6.1 Prioritisation of land

Participants had contrasting views on how land could or should be used. Interviewees with ideal soil type and topography for grapes were generally focused on utilising this land for grape production. This meant that setting aside land for greening was generally of a lower priority.

> *"No that was the only area we try to use as much I mean that you've got land and you want to make as much money as you can from it, So you plant as much as you can and yeah work it accordingly."-**VO9***
>
> *"**So you don't have any part of your land that's not suitable for grape production?** No, they are all their own undulating. So the difference is not significant."-**VWO1***
>
> *"We haven't actually got any. Everything is used and even the areas that I would at the moment I wouldn't because we have to get into those areas to trim trees or two. Yeah. Yeah so no."-**V3***

When asked about whether some areas produced bad quality grapes and if this meant they would remove vines to focus on quality grapes an interviewee indicated that they would use inputs and management techniques to control the quality of the grapes on lower producing land. For one grower the production of grapes even if it meant more management was worth the added effort.

*"**So do you have any that is considered as land that doesn't produce good quality?** We don't think that. It's probably more management. But you see you've got different management techniques. You may apply more or less water."-**VWO1***

*"**Yeah, so would you take consider taking them out or they're still productive enough to keep in**? No. No, it's fine they are nice vines It's just you got to go and handpick them."-**VWO1***

Properties with land unsuitable for grapes such as gullies, low-lying areas, waterways and oddly shaped areas said that they recognised these areas as suitable for planting non-vine species, they had planted these areas either through their own volition or via the Greening Waipara scheme.

*"Yeah. Yeah, we've planted up a sort of along the galleys in the Stream that runs through both properties of native plants just to try. I think when they first came on to (*their property*) and particular the stream was really overcrowded."-**V2***

*"We just have to generally the plantings that we will do will be. A sort of out of the vineyard or a place that's easy to fence around and they aren't kind of in the middle of the vineyard."-**V2***

Some vineyard managers and owners had land that was not used for grapes. However, this land was usually set aside for grazing sheep or pigs with little or no non-vine planting. This use of land seemed to be preferred over a cropping system or non-vine planting, most likely due to financial reasons.

*"We have plans for some smaller plugins on the bottom in the area we've removed from the vineyard where which we're now using to raise pigs and sheep."-**VO2***

*"**Do you manage that bit of land?** that's leased out to the farm, to the sheep farmer."-**V01***

*"Yeah, I guess the other thing is because we've got sort of a really nice agreement with our farming neighbours here. Yeah, and so we have this kind of spare land and they are just grazing it, so we've kind of just let it be."-**V3***

One vineyard indicated that they were considering or planning to put some more vines into the sheep paddocks on their property but did not mention any non-vine planting planned as a part of this venture.

*"Three sheep paddocks that are down there at the moment planting those as well."-**VW1***

This was closely linked to the previous land-use in the area, with all the participating vineyards having a previous use as sheep and/or beef farms. This allowed the growers to utilise all land ideal for grapes, as sheep/beef blocks usually consist of a square-shaped paddock with shelterbelts along the prevailing wind's fence lines. Although not directly asked during the interviews, a few interviewees mentioned that having greening on their properties would be made easier if they had something to work with rather than a relatively bare landscape. Growers also expressed that it was a shame to remove existing greening from their properties such as the pre-existing shelterbelts. For this reason, previous land use is also a barrier in the region.

*"That (*names vineyard*) used to be a beautiful farm with amazing shelterbelts all over it. And when they bought up, they ripped them all out every single one."-**V3***

Certified growers are required to have farm plans. When asked about what was on these farm plans and while looking at their farm plans, it was observed that they are focused on the production of grapes. This focus was also reflected in the interviewees' answers regarding what farm plans are used for. This acts as a barrier as the vineyards are not encouraged or are not engaging with their whole properties or viewing them as a whole system with both vineyard and green components working together. When asked about their farm plans growers often initially discussed how they planned their blocks of grapes and row orientation. One grower didn't use or think that farm plans were useful for anything other than gaining certification.

"*Well, you tell me. Apart from trying to do a project, you tell me how maps going to be useful to me? I mean what's useful is the number of rows of Riesling. All right, how many vines are in there? That's what you want to know because that's going to affect, you know your production right. Oh, and your management right?"-**VWO1***

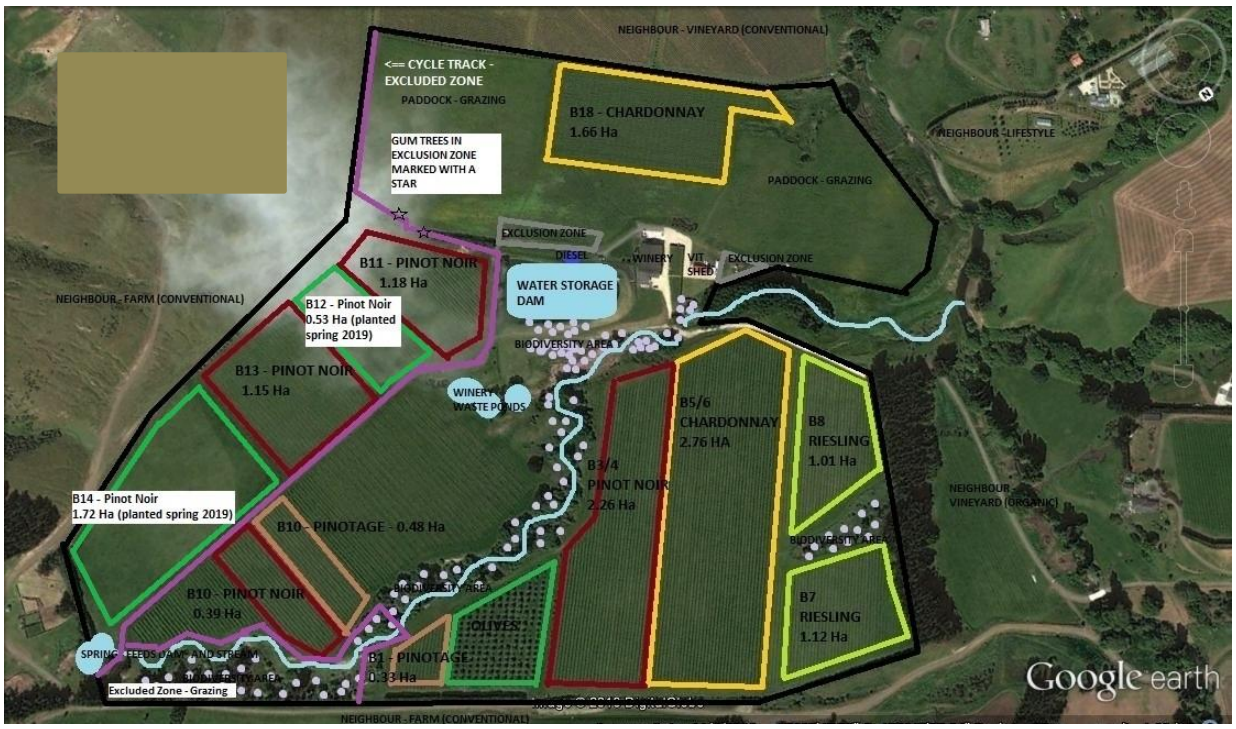

Figure 32 Example of a holistic view farm plan, showing both production and green elements present (provided by interviewee).

Figure 33 Typical example of a farm plan with a focus on production and variety type (provided by interviewee).

The above two figures (32,33) provide two different examples of farm plans. Figure 33 **i**s a typical farm plan that was given to us by vineyard managers or owners. It focuses on production and has the varieties laid out on a google map sometimes with the buildings and chemical sheds identified on the farm plan. Figure 32 is a more uncommon example. It comes from one of the organic farms. It has biodiversity sections identified on the map as well as the varietal types, streams and riparian plantings. This style of farm plan could encourage other growers to engage in their whole property as a system and encourage the thought process to include the ecosystem services that each aspect on the farm plan will provide for both the production of grapes and alternate incomes.

4.6.2 Marketing Value for Wine Sales

The marketing of the Waipara/North Canterbury region and individual wine labels could be classified as both an enabler and a barrier for the implementation of green infrastructure. Some of the interviewees were unsure about the extent to which greening could play a role in the marketing of North Canterbury wines with one interviewee suggesting that the greening element in Waipara only attracted small groups.

> *"**So do you think the non-vine planting has played a role in that marketing**? It attracts certain groups of people, but they are like small groups, you know like a campervan or a minivan."-**VWO1***

There was also a common uncertainty in how well the region had identified itself as something different to other wine regions in New Zealand and a view that the region's identity had gone through phases over the past ten years.

> *"I don't know how successful we really been in marketing ourselves is something different. I think we probably should have established. You know that we have the climatic change and that we're on the knife-edge of cool climate viticulture and I sort of see us as one cooler. But we haven't really probably established ourselves as really different region."-**V7***

> *"Ah it keeps changing. Yeah for a while. It was all about being green. It was a weird tag line that they had. But now I think it's they're just trying to sort of push the small, quality side.*

Focusing on the land, you know trying to get the food and wine information going and actually going so they're doing a lot of those foraging events."- ***V2***

Due to an apparent confusion regarding the region's identity, some vineyards had focused on how their own vineyards were marketed.

*"I don't know the Greening Waipara. I don't know how far that's kind of got recognised. I can't see it happening and we've, for us we already know what we're doing the vineyard that's not really part of it. But they got this nice little trail right here."-****V3***

A common answer regarding the region's identity included the mention of the regions large proportion of small family-owned vineyards that produce quality wines.

*"And we're starting to get a lot more attraction and it's also because a lot of a lot of these smaller wineries that have come through are just producing such good wines now and we're getting a really good name for Pinot Noir especially."-****VW1***

*"I don't think the greening part of it is actually that important in terms of establishing identity. The reputation of a district. The quality of the wine does that, but it certainly gives you a measure of how the people are thinking."-****VO6***

This factor, combined with sustainable practices and the legacy left by the Greening Waipara Project, could provide a point of difference for the region to build its identity around.

4.6.3 Certification Requirement and Enforcement

The majority of the vineyards are either Sustainable Winegrowers New Zealand or Bio Grow certified. These certifications require the vineyards/ vineyard wineries to meet certain standards and requirements on their properties. This results in a dynamic of enforcement between the producers and their certifications. Participants were asked what greening and non-vine plantings their certifications required, the answers provided varied in detail.

*"****I suppose the same question for SWNZ do they encourage non-vine plantings****? Yeah I think so they all ask for maps and they want to see you do something for biodiversity. They do encourage it and they do sort of your advertising themselves as such you know."-****V3***

*"**Whats the point of SWNZ then?** Marketing. **And do you think they encourage non-vine planting what are they**? I couldn't say? **Do you know who's involved in developing their practices?** Not personally. Yeah, best talk to them."-**VWO1***

Despite not knowing in detail what policies SWNZ had regarding non-vine planting, many growers thought that the policies they had and the purpose of the certification was beneficial to their vineyards and the industry as a whole.

*"**What policies does SWNZ have for your level of greening?** For non-Vine planting? No, not that of I would have seen or would have even read about. But I mean they I think for SWNZ that's quite good because they have a lot of people that do all of that research and they're good people to talk to, and they are very willing to help you because I mean, that's the whole program. Trying to make New Zealand wine sustainable and very environmentally friendly, I would say."-**VW1***

*"I think they've got some good policies on that (*vineyard greening*). **Do you know what kind of policies those are?** Well depending on which non-vine planting your talking about. They are definitely encouraging a good kind of inter-row sward. And I talked about getting more species diversity in there. And I think that's a good thing to talk about. You know. **Did they give you any kind of methods on how to do that?** They possibly do, but I guess we've been doing it for a pretty long time. So I didn't really pay much attention to that."-**V3***

*"**Do you think that's (SWNZ) helping people to implement more non-vine**? Ahh probably not, I mean probably, just, I think if you're living on the place and what I call a small grower, you're probably thinking about the whole plan. Yeah, and if you're a big company your probably doing the same thing. Yeah, I think people are pretty much aware of it (*Greening*) and are probably going to maximize the area for grape planting first and then think about it. That's what they (*SWNZ*) are trying to do."-**V7***

Growers certified with the organic certification Bio Grow also gave a variety of answers when asked about the level of non-vine plantings encouraged or required by their certification.

*"**What kind of what do they (Bio Grow)require in terms of non-vine planting and greening?** Yeah, they do encourage it yeah they have a buffer zone of 8 meters around the vines."-**V7***

*"**Would you say The Organic certification focuses on non-vine planting in the vineyard?** I don't it doesn't really make up a big portion of the certification no I think you could have pretty*

minimal plantings. ***What about the cover crops****? Yeah, it all helps, but you don't have to do that. Yeah. You've got just have good plans in place to be managing your soil and organic matter things like that."-****VO2***

*"****So that's a requirement of organic is it?*** *Yeah, we just need to show that we are improving the environment. Yeah, encouraging biodiversity into the vineyards." –****V2***

The answers above show conflicting beliefs and confusion among participants around what their certifications require. When asked about what SWNZ required for vineyard certification, some vineyards indicated that a lot of the certification is around ensuring correct spray use and storage and that the audits focused on making sure everything is recorded throughout the year.

*"Think is going back to SWNZ as you know, they do make sure those systems are in place now. The audits they do is I'll come through and check sheets up to speck. Yeah, make sure you store it (*chemicals*) right and all that stored that because you've got your folio feeds or you know, you may be using fungicides you're trying to get every category separate."-****V8***

*"So they require everything you do on your vineyard has to be tracked so spray history track chemical are Recorded and the quantities, your outputs."****-VO5***

Having a certification is not a requirement for growers; some of the smaller vineyards involved in this study did not have certifications (Figure 34). This due to it not being financially viable for them to do so as the fees for the certification were not justifiable given their outputs. The three vineyards without certifications did not appear to have less greening than their certified counterparts.

*"No, I'm not. I just, I hide from a lot of those people, on this scale. It (*SWNZ certification*) really isn't viable."-****VO8***

*"Sometimes the cost (*of certification*) on this scale just not worth it"-****VO2***

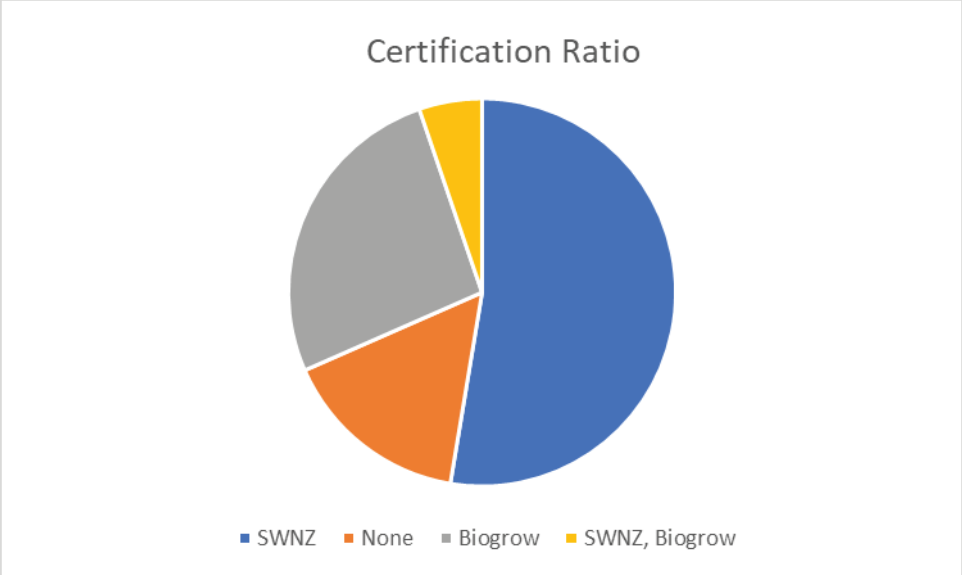

Figure 34 Ratio of different certification types between interviewee's

4.7 Summary

The Table 4 below summarises: the green infrastructure (GI) components present within vineyards; where they are located; what ecosystem services and dis-services are associated with each GI component; and the enablers and barriers for the implementation of each GI component and for GI in general. The green infrastructure in the visited vineyards was located both within and separate from production land. The green infrastructure, that was not directly related to production, was generally located on land unsuitable for grape production and around areas related to human activity. The main greening components that were present in all the vineyards visited during this study are cover crops and shelterbelts with landscaped plantings also being a common feature around buildings and entranceways. The following chapter discusses the results from this chapter in terms of the literature, delves deeper into the value of and implications for GI in this real world situation, and what practical steps would be needed to implement these findings.

Green Infrastructure Component	Location	Ecosystem Service	Ecosystem Dis-Service	Enabler/Barrier
Cover Crop/Sward	Cover Crops and Sward covers was found between the rows of vines in all participating vineyards	•Biological control •Soil Quality	•Health and safety risks	•Ecosystem Services and Dis-services •Mangement Benefits and Consequences •Knowledge
Hedgerow/Shelterbelt	Hedgerows/Shelterbelts were located along the boundaries of participating vineyards and between the boundaries of vine blocks within the vineyards	•Micoclimate •Disease Control •Aesthetic/Cultural •Biological Control	•Microclimate •Competition	•Ecosystem services and Dis-services •Mangement Benefits and Consequences •Knowledge
Vegetated Patches	Located in areas of the vineyard unsuitable for grape production,	•Errosion Control •Aesthetic/Cultural	None identifyed by interviewees	•Ecosystem Services and Dis-Services •Management Benefit and Consequences •Knowledge •Funding •Commitment
Water Patch/Corridor	Located along streams within the vineyard properties and around ponds, dams and galleries	•Water Quality •Aesthetic/Cultural	None identifyed by interviewees	•Management Benefits and Consequences •Ecosystem Services and Dis-Services •Commitment
Landscaped Planting	Located along entraceways, roadsides, around cellar doors and vineyard related buildings	•Aesthetic/Cultural	None identifyed by interviewees	•Ecosystem Services and Dis-Services

Table 4 Summary of results giving the location, recognised ecosystem services and dis-services along with the enablers and barriers identified for each GI component

Chapter 5

Discussion

This chapter discusses the implications of the findings in the context of the literature review, provides the implication of the findings for implementing green infrastructure (GI) and ecosystem services and explores the areas for further studies regarding the enablers and barriers for implementing GI.

5.1 Are Vineyards following a biodiversity strategy, and is it a sharing or sparing strategy?

The location of green infrastructure in this study can be categorised as land sharing or sparing. The nature conservation and insectary habitats in this study fulfil the definition of land sparing, where the plantings are separate from production and land set-aside for conservation (Green et al., 2005). On the other hand, cover crop/sward planting and adjacent areas utilised for hedgerow components around the vine rows constitute a land-sharing system where the green infrastructure is integrated within the production area (Jacqueline and Henrik Von, 2018). This may be due to the recognised value of integrating cover crops, swards and shelterbelts into the production system being higher than the recognised value of other components such as vegetative patches. This tendency for land sparing locations of green infrastructure is supportive of Balmford et al. (2005) statement that the notion of land-sparing strategies is widely advocated for within agricultural development and literature. A study of vineyards in Oregon's Willamette wine region found that sparing green infrastructure was implemented at a farm-scale in support of certification requirements, nature conservation, and for wine branding and sales, but received less design or management attention (McWilliam, 2020). These findings are also true of the Waipara wine region. The GI components that were not directly related to production were largely implemented in areas unusable for grape production to meet certification requirements, increase biodiversity or add to the vineyard experience and aesthetics.

5.2 Significance of the GI implemented in vineyards for the provision of multiple ecosystem services

The ecosystem services identified by the participants in this study broadly matched what is reported in current literature, but to varying degrees. The level of the participants' understanding of the services each component provided was often a reflection of the amount of targeted/digestible/industry literature available and the motivating factor of directness of the service for grape production. The sections below explore; the significance of each GI component for the provision of multiple ecosystem services and how these components might be improved to benefit both the grower and the landscape.

5.2.1 Cover Crops and Swards

Cover crops have a varying impact on production depending on the climatic conditions. Klodd et al. (2016) reported in their study on cover crop competition that grapevine root systems are capable of acclimating to understory grass competition, but specific resource limitations are strongly context-dependent. Although participants in this thesis were not concerned about cover crop competition, they were reluctant to let grass grow uncontrolled directly under the vines due to competition. The finding by Klodd et al. (2016) suggests that this concern may be less important than they perceive. The high uptake of cover crops and swards found in this study has also been reported elsewhere (McWilliam, 2020, Winkler et al., 2017). In line with McWilliam (2020), this thesis found that all participants had swards or cover crops between their vines with no vineyards opting for bare soil to be exposed. This was expected given the ample research regarding the benefits of cover crops and inter-row swards and the services they provide within the vineyard. These services are increased biodiversity, biological control, erosion control, trafficability and soil organic matter (Garcia et al., 2018, Van Vooren et al., 2017). In alignment with these multiple services listed in the literature, the interviewees emphasised biological control followed by nitrogen fixation by oats and clover species, organic matter, and moisture control as the principal benefits received or related to their cover crops and swards. Despite these services being recognised participants did not mention the services that

surrounding GI components may provide for supporting cover crop insect populations. To maximise the benefits received by cover crops and volunteer swards this knowledge outreach should be strengthened to ensure that maximum ecosystem services are gained from within their system.

5.2.2 Shelterbelts

Jackson (2008) discuss the role of shelterbelts in the vineyard landscape. They suggest that unless strong winds are a characteristic feature of a region, wind seldom is considered in vineyard selection or row alignment. In Waipara, the strong nor-west wind is of concern to the growers. The ecosystem services that growers associated with their shelterbelts were related to wind protection due to the presence of a strong nor-west wind in the region. Within the literature, it is suggested that hedgerows and non-crop woody habitats increase the biodiversity value of farms (Heath et al., 2017). This was not a frequently identified service that was recognised by the interviewees in regards to their shelterbelts during this study. Shelterbelts were primarily seen as functional with little to no thought regarding their species makeup. A disservice identified by the growers was decreased vigour and yield in rows adjacent to the shelterbelts. This loss of yield is in keeping with the literature. Van Vooren et al. (2017) have reported that in their study although the yield was decreased up to 25 meters away from the shelterbelt, that the yield was increased between 25 and 50 meters away resulting in a net yield of 103% from a ten-meter high hedgerow. This indicates that hedgerows have the potential to have an overall positive effect on crop yield. Frugivorous birds were also a disservice that many interviewees identified. This disservice has been reported by multiple studies on the impact of bird predation within vineyards. One study reported that in a California vineyard, 40% of damage occurred at the edge of the vineyard, with 12% of grapes damaged by bird species (Kross, 2016). Acting as ecosystem services providers, insectivorous birds may also act as predators on insect pest species within the vineyard (Barbaro et al., 2017, Kross, 2016), no studies were found in the literature studying the impact of New Zealand native insectivorous bird species that act as a biological control in vineyards. Both studies call for more research to be done regarding the cost-benefit analysis of bird species within the vineyard and level of heterogeneity within the system.

Overall, Growers concerns regarding shelterbelts included the roosting of pest bird species, competition with vines and unwanted effects on the microclimate are validated within the literature (Kross, 2016, Jackson, 2008). However, the merits and dis-merits of shelterbelts should be assessed on a site by site basis (Jackson, 2008). Although the ecosystem disservices are supported by the literature, the extent of disservice may not be as pronounced as believed by the individual growers with the provision of multiple ecosystem services and interaction with other components having the potential to supply more net benefit. Zhang et al. (2007) present an array of ecosystem disservices that reduce agricultural productivity and/or increase production costs, however the flows of these services and disservices rely on how the agricultural systems are managed at the site scale and on the diversity, composition and functioning of the surrounding landscape. To gain the most function from shelterbelts the species makeup, surrounding infrastructure and resultant net benefits should be examined further.

5.2.3 Nature Conservation and Insectary Habitats

McWilliam (2020)) reported in their study that a minority of interviewees established small insectary patches outside of their vineyard blocks on land unsuitable for grape production, often in wet lower lying areas of farms. They believed they provided beneficial insect habitat supplementary to that of meadow cover crop rows. This finding was not supported by the majority of interviewees in this study, participants did not view their nature conservation and insectary patches as connected to their cover crops or swards. However, insectary patches did exist within the majority of vineyards. These areas were predominantly implemented as part of Greening Waipara. Participants were however aware that they acted as habitat and increased the biodiversity within the farm. Studies have shown relationships between insectary plantings and cover crops. Nicholls et al. (2001) measured the abundance and dispersal of insects along vegetation corridors in a Northern California organic vineyard. The presence of riparian habitats also enhanced predator colonisation and abundance on adjacent vineyards. They reported that the corridor amplified the influence of pest-predator species by enhancing timely circulation and dispersal of these predators into the centres of fields. Altieri et al. (2005) have observed that islands of flowering shrubs and herbs provide season-

long resources for natural predator insect species and can act as push-pull systems for natural predators, enhancing their activity and confining them to adjacent rows. They suggest that strip plantings could overcome this push effect of island plantings. Despite this research the responses given during this thesis suggest that growers are not aware of the interactions between the green infrastructure components in their vineyard system. For the provision of multiple ecosystem services in vineyards these two components need to be better managed, connected and shared with growers.

5.2.4 Waterways and Ponds

McWilliam (2020) found in their study that woodland patches were often connected into corridors centred on rivers or streams. This was also true of Waipara where many of the vineyards that had waterways, had retained or allowed species to regenerate in these areas. Although also in keeping with this study with one exception, growers did not actively plan these areas. An inventory of the plantings along and around the waterways in the Waipara catchment would better evaluate the regional connectivity around waterways and identify gaps and key areas for future plantings. Studies have shown that waterway and pond plantings can support and encourage services from multiple components in the vineyard such as supporting beneficial insect populations (Altieri et al., 2005, Nicholls et al., 2001).

Off-site transport of contaminants in the form of nutrients, sediment and pesticides from agricultural practices has been reported in the literature as a concern to landholders, regulatory agencies and the general public (Cox et al., 2012). However, this was not recognised by growers in this study. Buffer strips, sedimentation ponds and wetlands are however methods that minimise off-site dispersal of excess nutrients and sediment (Cox et al., 2012). As with McWilliam (2020) interviewees also indicated their key ecosystem service was to support regional biodiversity, with many believing they did not benefit their production systems, nor were they planted for run-off mitigation.

5.3 What are the Main Enablers and Barriers for Implementing GI in Wine-Grape Vineyards

The enablers and barriers identified in this study were: potential for ecosystem service and disservice provision, management benefits and consequences, access to implementation knowledge, access to funding, level of commitment, prioritisation of land, marketing value for wine sales and certification requirement and enforcement. All these factors are inter-related, for example, levels of commitment will be impacted by both the level of knowledge and perceived needs for ecosystem service/disservice provision. The enablers and barriers identified during this study align with the themes that emerged from the research that was explored in the literature review (Landis et al., 2000, Shields et al., 2016, Mitchell, 2001).

5.3.1 Potential for Ecosystem Service and Disservice Provision

The need or promise of receiving ecosystem services was an important driver for the implementation of cover crops, swards, shelterbelts, conservation and insectary habits as well as landscaped plantings in this study. Conversely, if the risk of ecosystem disservice was perceived as high by the viticulturists they were unlikely to implement the GI associated with this disservice. One study that looked at the management and recognition of ecosystem services and disservices of an invasive species discussed that different groups of people derive differing benefits from ecosystem services and value those services differently (Tebboth et al., 2020). Therefore, when including stakeholders in the assessment of trade-offs between ecosystem services, the values they ascribe to these outputs will depend as much on the ecosystem as it does on how they experience its services or disservices (Tebboth et al., 2020). This is relevant to this thesis' finding that the GI component that was most valued in all vineyards had the most direct benefits to grape production. When participants recognised the benefits of implementing a GI component or identified a need for an ecosystem service that could be provided by the associated GI components implementation was high. This was also supported by Cullen et al. (2013) who suggest that agriculturists with the greatest need to

resolve or mitigate an environmental challenge are the most likely to adopt the associated innovation.

5.3.2 Management Benefits and Consequences

The consequences of integrating GI into the vineyard are of concern to the participants in this study, especially in regards to GI components that follow a sharing strategy in the vineyard landscape. Shields et al. (2016) identified disruption to vineyard practice and time commitment as a barrier to the planting of natives species in vineyards. They attributed this to the fact that at the time of their study, this practice was still in the research phase with protocols yet to be made available to winegrower. Despite this barrier, it seems that insufficient effort has been applied to conveying information about how these biodiversity-based farming practices can be applied on large scales. Nevertheless, this thesis found that the reduction of vineyard management effort/tasks resulting from cover crops was an enabler to the continued integration of this GI component in the vineyard, due to a reduced need for the much more onerous compost application.

5.3.3 Access to Implementation Knowledge

Throughout the interviews a barrier emerged repeatedly concerning the dissemination of knowledge about GI implementation. Growers were unsure of how to plan GI components, what to plant and where to plant. This view was equally noted by both Shields et al. (2016) and Landis et al. (2000). There was in their experience, a particular lack of knowledge surrounding the use of plants that suppress weeds beneath vines. Landis et al. (2000) also found that there was anxiety surrounding the selection of correct and appropriate species. Many of my participants looked to a local nursery to gain knowledge and assistance regarding what to plant and where to plant their nature conservation and insectary habitats. This suggests that, although knowledge is a barrier for implementation, growers are willing to find resources to overcome this barrier. A concern remains however, that advice from various sources may be inconsistent and sometimes inappropriate to particular properties or situations. This suggest that more protocols and knowledge regarding implementing GI needs to be provided to the growers in order to overcome this barrier. In agreement with Shields et

al. (2016), Daryanto et al. (2019) suggest that of equal importance is the need for education and technical assistance regarding post-establishment management challenges around introducing cover crops into a farming operation.

5.3.4 Access to Funding

A lack of access to means was a potential barrier for implementing environmental policy, according to Mitchell (2001). Shields et al. (2016) findings support the statement made by Mitchell (2001) by identifying the cost of initial investment as a potential barrier for the implementation of endemic species under-vine in their study. However, this thesis has observed that vineyards were enabled by access to both external or internal funding for the implementation of native plants and green infrastructure in their vineyards. As many participants were committed to planting areas of their properties with natives and willing to spend time applying for funding to do so.

5.3.5 Level of Commitment

It was apparent that those who had implemented GI into their farm systems often displayed a high level of enthusiasm and commitment to greening, while those without this enthusiasm had less non-production related greening present. Level of commitment was identified as a barrier for implementation by Mitchell (2001) and Landis et al. (2000) who found a generalised reluctance by the agricultural/horticultural community to proposed habitat changes as a potential barrier to implementation. Shields et al. (2016) however found that the majority of their respondents indicated that they would 'definitely' or 'maybe' deploy indigenous plants around or within their vineyard properties for the various uses presented to them. This shows that there was an initial expression of commitment by the vineyards in the Waipara region to develop endemic plantings. This study identified this as both an enabler and a barrier across each of the interviews due to differing management structures and presence of individuals within each vineyard. Vineyards with autonomy over management decisions and/or the presence of a champion employee/owner were committed to supporting biodiversity within the region and their properties. While vineyards with constricting

management policies and/or did not value biodiversity as highly were less committed to implementing GI in their vineyards.

5.3.6 Prioritisation of Land

Vineyards in this study followed a mixture of sharing and sparing farming strategies and showed little to no planning or mapping of GI components in their vineyards. Interviewees tended to view their productive land with higher regard than areas of their property that were not utilised for grape production. This was due to a focus on maximising the land available for maximum profit and production. This meant that growers were reluctant to implement non-vine planting in areas where grape production was occurring. McWilliam (2020) found that their interviewees were only interested in growing grapes that would result in quality high priced wines. If participants had land that was not suitable for this purpose, they would not grow grapes on this land. In contrast to this, the participants in Waipara utilised all available land for grape production, even marginal areas. McWilliam (2020) also observed that farm scaled sparing GI was implemented in support of certification requirements, nature conservation, and of wine branding and sales, but received less design or management attention. This is also an accurate description of the Waipara participants, farm plans in this study were solely production focused with little to no GI components shown. By only placing viewing and mapping the productive land on their properties growers are losing the potential for maximum ecosystem services that well designed and connected GI can provide. This is a potential barrier for the implementation of GI and ecosystem services provision in the vineyard landscape.

5.3.7 Marketing Value for Wine Sales

The marketing of the Waipara region has taken on many forms over the past decade. Interviewee responses focused on their identity as small, family-owned vineyards that produce quality wines. This focus on quality is similar to the participants in McWilliam (2020) study, where participants product sold for upward of $30 US. Sustainable marketing provides an opportunity for the growers of the

region to differentiate themselves from other wine regions in New Zealand. This is critical for small regions and producers to be recognised in an overcrowded market (Forbes et al., 2009). Waipara is a small and often overlooked region, the Greening of Waipara provided a point of difference to other wine regions. However, participants in this study did not value their biodiversity for its potential marketing service. Of the three vineyards in this study with biodiversity trails, only one participant mentioned its use by visitors. This is in keeping with Fountain and Tompkins (2011) study that found although the biodiversity trail added to the winery experience only 22.8% of respondents agreed that the experience made them more likely to buy wine during their visit. Fountain and Tompkins (2011) concluded that vineyards need to find a way of ensuring that the knowledge of viticulture practices and the impact of the measures they take to avoid this impact is shared with potential consumers. When asked about the benefits growers received from their landscaped plantings, many participants showed a belief that focusing on cellar door gardens held more value than biodiversity trails. The study by Fountain and Tompkins (2011) on the potential of wine tourism experiences to impart knowledge of sustainable practices found that the presence of the biodiversity trails added to the winery experience, and that one-fifth reported that they would be more likely to purchase wine from the winery because of their experience. There is potential for GI to add marketing value to the vineyard, this would be a driver for vineyard owners and managers to add more GI components into their vineyard systems.

5.3.8 Certification Requirement and Enforcement

A barrier for the implementation of GI was a level of confusion regarding what level of biodiversity was required my certifications in the region. Mitchell (2001) identified dynamics of enforcement as a potential barrier for the implementation of environmental policy, for the purpose of this study this barrier was identified in regards to the two certification practices in the region (SWNZ, Bio Grow) and the level of understanding and enforcement of these certifications within each of the vineyards. The majority of vineyards involved in this study had certifications through SWNZ and/or Bio Grow Organics. However, there was considerable variation in the participants understanding of the

requirements of SWNZ in regards to non-vine planting in the vineyard, especially biodiversity plantings, and the requirement and purpose of the farm plan. The level of vineyard manager/owner participation and interaction with the certification requirements could be a potential barrier for the implementation of green infrastructure, particularly vegetated patches/ biodiversity plantings in the vineyard/ vineyard wineries.

5.4 Implications of the Enablers and Barriers Identified for Viticultural Theory and Practice

The enablers and barriers identified in this study have implications for policymakers, academic agriculturists, and indeed the culture of 'clean green Aotearoa-NZ. In order for increased implementation of GI in vineyards and agricultural systems to occur the enablers and barriers outlined in this thesis need to be addressed. It is important that certifications and local and national government policymakers take these enablers and barriers into account when developing methods, messaging and rules surrounding the implementation of GI and biodiversity-based farming practices in vineyards. The enablers and barriers identified in this study also have implications for researchers and the academic community. They provide an insight into the challenges that future initiatives and GI components need to overcome through research, technology and social engagement in order to be viable in a commercial setting. These enablers and barriers also have implications for the wider agricultural community regarding GI and environmental policy implementation within farming systems. When viticulturists and agriculturists are made aware of what enablers and barriers they face in terms of implementing GI, they are better positioned to communicate their needs to their certifications, policymakers and academics. For this reason, all industry organisations, policymakers and academic communities interested in the implementation of GI in both vineyard and agricultural systems should engage with all stakeholders to better identify what enablers and barriers identified in this study are present in their systems and how they might be overcome.

5.5 Limitations of this Study

One limitation of this study is the sample size; 19 interviews were conducted from a possible 24. It was essential that the interviews were carried out with those who had previous experience implementing greening While this sample size requires caution to be exercised when extrapolating these results too far, the comparison and convergence with other studies, regarding green infrastructure and vineyard design McWilliam (2020) allows for more robust conclusions. This limitation does however highlight an opportunity for similar studies to be carried out in other wine regions and the potential for a meta-study regarding enablers and barriers to implementing GI in wine-grape vineyards. A second limitation of this study is an aspect of the methodology. Whereas all interviews were based around a common set of questions, there were also some more probing queries specific to each interview that meant comparison across participants in these areas was not possible. Furthermore, qualitative analysis required judgement and interpretation of the results by the researcher. For this reason the themes identified in this thesis reflect an informed interpretation of the data and participants responses while checking against relevant literature. To mitigate this, the themes identified in this research were compared with the available literature regarding the enablers and barriers for implementation of both policy and individual green infrastructure components.

5.6 Implications for Further Research

This study identified the enablers and barriers surrounding the implementation of green infrastructure in vineyards. Further research is required to build the current understanding of the challenges regarding the implementation of green infrastructure further. Firstly, it was found that components followed either a sharing or sparing pattern. It was also found that vineyard farm plans had sparse amounts of information regarding what GI components were present. Further research should be carried out to analyse the design and layout of green infrastructure components within the vineyard landscape to allow for the assessment of the level of connectivity between components. This is important for the development of green infrastructure and its ability to provide ecosystem service both on a regional and farm scale. Secondly, further research should be carried out to

investigate the relationship between the enablers and barriers found in this study. By doing so further insight regarding how to better implement and encourage GI uptake within vineyards and possibly other industries may be gained. This would allow for more rapid uptake of GI by practitioners. Thirdly, the impact that addressing the barriers and encouraging the enablers identified in this study might have on the long-term longevity of GI implementation projects within wine-grape vineyards should be explored further. Finally, further research into the interaction and provision of multiple ecosystem services by the presence and management of a green infrastructure vineyard system should be carried out to explore this further and allow for more knowledge for industry professionals aiming to maximise net benefit from their GI.

5.7 Summary

This chapter critically reviewed the findings of this research in the context of the literature and the results section to validate or cast doubt on the findings. Section 5.1 discussed what biodiversity strategy vineyards were following, concluding that both sharing and sparing strategies were being used across the study site. Section 5.2 explored the perceived significance of the GI implemented in the participants' vineyards. Section 5.3 explored the enablers and barriers identified in this study, providing a comparison with examples from the literature. Section 5.4 provided the implications of this study emphasising the need for the enablers and barriers identified in this study to be addressed by policymakers, certifications, academics and viticulturists. Section 5.5 provided the limitation of this study. Finally, recommendations for future research were discussed. The following chapter concludes this thesis.

Chapter 6

Conclusion

GI provides a method of mitigating the environmental impacts associated with conventional viticulture. However, the enablers and barriers for the implementation of GI had not been critically studied (McWilliam, 2020). This thesis has aimed to address this gap and by doing so provide insight into the enablers and barriers associated with the implementation of GI and highlight ways of strengthening enablers and mitigating disablers.

Using qualitative interview methods, this thesis explored the location of green infrastructure in the participating vineyards, the ecosystem services associated with each GI component and the enablers and barriers for implementing GI in the participating vineyards. It was found that participants followed both sharing and sparing biodiversity strategies in their vineyards. GI components that provided direct benefit to production such as cover crops, swards and shelterbelts were integrated into the system (sharing), while GI components such as nature conservation habitats and waterway plantings were located away from production on un-usable land (sparing). The ecosystem services that participants associated with each GI component are largely matched the current literature. However, growers were best able to identify the value of services related to their land-sharing GI components than those sparing components that were away from productive areas. The enablers and barriers identified in this thesis are potential for ecosystem service and disservice provision, management benefits and consequences, access to implementation knowledge, level of commitment and access to funding. Additional factors surrounding the implementation of GI in wine-grape vineyards were also found during this study. They were not related to the implementation of individual components of GI, but to the integration of the concept of GI as a whole. They were prioritisation of land, marketing value and certification requirements and enforcement.

The implications of the enablers and barriers identified in this study will impact or inform three main groups, these are policymakers, academics and viticulturists. In order to address the results of this study, all three groups (and the nation as a whole) need to recognise the barriers identified in this study and continue to encourage the enabling factors that were identified. Addressing and overcoming the barriers identified in this study would see an increase in GI implementation across New Zealand vineyards and provide a framework for increasing GI in various agricultural and horticultural systems.

Appendix A

Data Collection and Analysis

A.1 Interview Script used during the semi-structured interviews.

Background information	What is your role in the vineyard? How long? How large is this vineyard? Do you have others? What is your vineyards unique story or point of difference? Does environmental good practice play a role in this? How is Waipara marketed as a wine region? How does this effect your farm practice? What role do you think non-vine planting has in vineyards?-define nv
Nadege Questions	Did you design your vineyard? If not who did? Do you have a farm plan? Ask for copy **If no :** why not? **If yes :** Why? Do you use it to make decisions about your property? How do you make decisions / plan the design of your vineyard ? (land sales opportunities, soil, needs) What is recorded on the plan? Whole or just part property? Are the GI recorded? Why?
RQ1 What non-vine plantings existed, were planted and are currently in participant vineyards	How has previous land-use effected what non-vine plants you have on your property? I.e have you inherited any NV vegetation? What non-vine plantings do you currently have in your vineyard? Native, exotic, Where are plantings located and why are they located there? When were they planted? How do your neighbours plantings interact with your vineyard system? Does this impact your future plantings? Do you have any water systems? Is it planted? Why/why not?

RQ2 To what extent does the GI planted mitigate key environmental impacts and increase ecological service?	When planting what benefits did you focus on? Bio control, vigour etc What benefits do you think you've received? What about dis-service Do you think non-vine plantings have improved your property?-how What determines the quality of your wine when it comes to vineyard management?
RQ3 how might GI effectiveness be improved?	Do you prefer natives or non-natives? Why How do your plantings create a system or network within your vineyard? Are you currently restoring or planning any plantings?-where, why, how Do you think about what and where this vegetation is when you are planning/restoring yours? What does your certification require? Has it helped you to implement plantings? Are you involved in the development of certification practices? Who is?
RQ4 How might GI be increased in the vineyard? What are the enablers or barriers for its implementation?	What is the biggest barrier for non-vine plantings on your vineyard? Can you think of any things that you, SWNZ, the govt or the uni might to enable you to grow more non-vine vegetation? What % of land would you say is suitable for grapes on your property? What do you do with the rest? Are you aware of any funding for plantings? If you've applied, how was the process? How much management do plantings require? Who does this task? Would you be interested in working with your neighbours to connect your non-vine vegetation with theirs? Why/why not? do your neighbours plantings benefit or impact you?how,why,when Is there anything you would like to add that hasn't been asked? Thankyou!!

A.2 Interviewee Classifications

Interview	Intext Code	Vine(ha)	Certification	Ownership	Time	Gender	Education	Cellar door	Role	Cycle Trail	Accomodation
Interview 1	VW01	20	SWNZ	Single	1:37:27	Male	Industry	Yes	Owner,Manager	Yes	No
Interview 2	VO1	1	None	Single	1:21:26	Male	Uni	No	Owner,Manager	No	Yes
Interview 3	V1	13	BioGrow	Single	1:23:02	Male	Lincoln	Yes	Vineyard Manager	No	No
Interview 4	VO2	4	BioGrow	Single	1:27:29	Male	Uni	No	Owner,Manager	No	No
Interview 5	V2	50	BioGrow	Multiple	1:14:42	Female	Lincoln	Yes	Vineyard Manager	Yes	Yes
Interview 6	V3	70	SWNZ	Single	0:57:31	Male	Horticulture industry	Yes	Vineyard Manager	No	No
Interview 7	V4	210	SWNZ	Multiple	1:26:50	Male	Uni	Yes	Vineyard Manager	No	No
Interview 8	V5	3	SWNZ	Multiple	2:08:26	Male	Industry	No	Vineyard Manager	Yes	No
Interview 9	VO3	20	SWNZ	Single	1:03:13	Male	Lincoln	No	Owner,Manager	No	No
Interview 10	V6	330	SWNZ	Multiple	1:10:13	Male	Industry	No	Vineyard Manager	No	No
Interview 11	V7	23	SWNZ, Biogrow	Single	1:55:02	Male	Horticulture industry	Yes	Vineyard Manager	No	No
Interview 12	VO4	23.1	BioGrow	Single	0:52:23	Male	Lincoln	Yes	Owner,Manager	No	yes
Interview 13	VW1	9	SWNZ	Single	1:30:33	Male	Lincoln	Yes	Winemaker,Manager	Yes	No
Interview 14	V8	200	SWNZ	Multiple	1:45:55	Male	Industry	No	Vineyard Manager	No	No
Interview 15	VO5	7	SWNZ	Single	0:46:25	Female	Industry	No	Owner,Manager	No	No
Interview 16	VO6	1.5	SWNZ	Single	1:36:13	Male	Industry	Yes	Owner,Manager	No	Yes
Interview 17	VO7	6	BioGrow	Single	1:07:46	Female	Industry	No	Owner,Manager	No	No
Interview 18	VO8	0.5	None	Single	1:29:16	Male	Industry	Yes	Owner,Manager	Yes	Yes
Interview 19	VO9	4	None	Single	0:40:37	Male	Industry	Yes	Owner,Manager	No	No

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